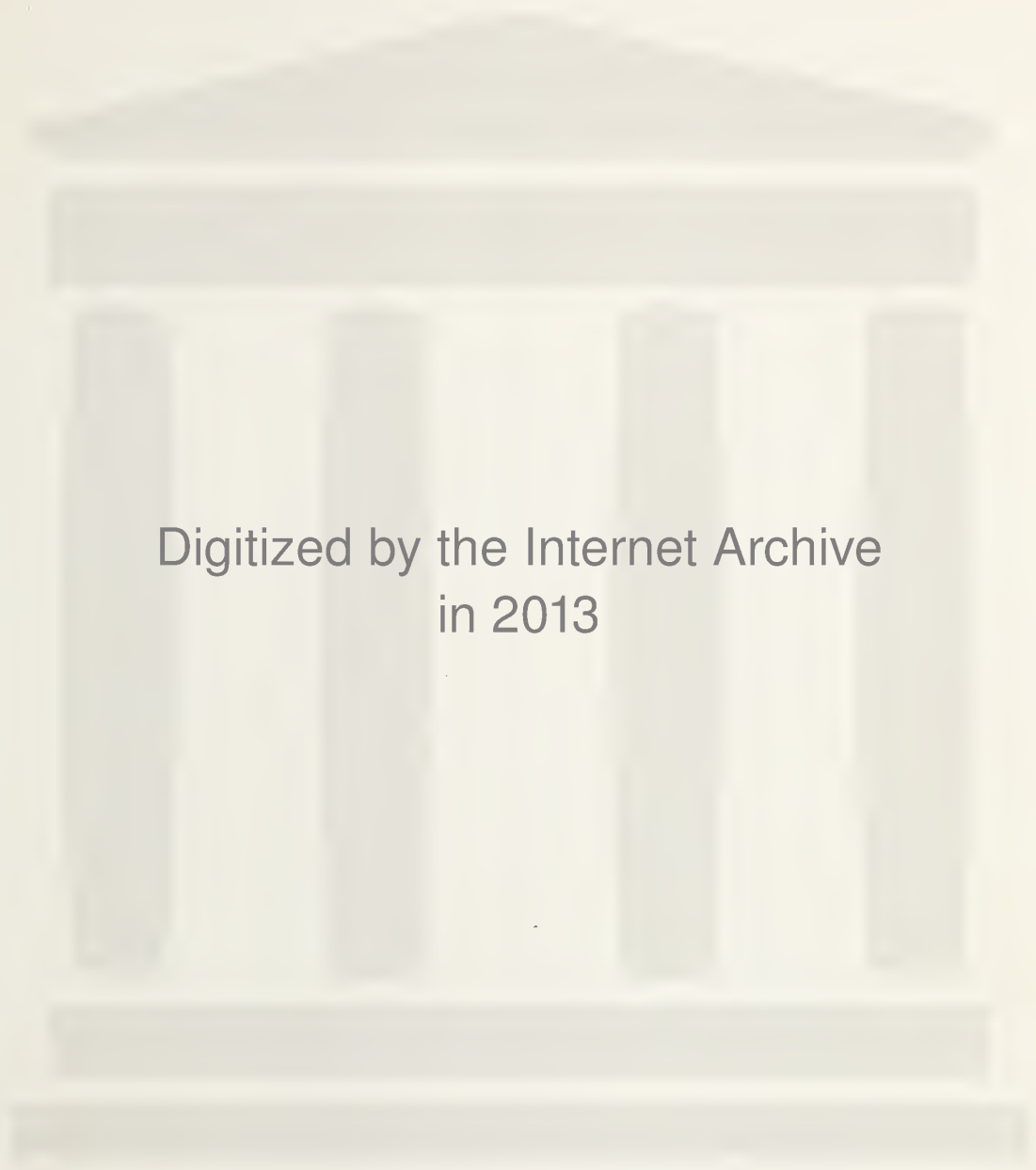






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PROCEEDINGS

American Society
of
Sugar Cane Technologists

Volume 1 - Papers for 1971

Florida and Louisiana Divisions

ASSCT

December 1971



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FOREWORD

This marks the first volume of Proceedings published following the reorganization of the American Society of Sugar Cane Technologists into two divisions. It contains papers presented at all meetings during 1971.

There have been seventeen previous volumes published since the ASSCT was founded in 1938.

This volume is arranged in three parts. The first part contains papers presented at the first annual joint meeting held in Pensacola, Florida in June 1971. The second part contains papers presented at the Florida Divisional Meeting held in West Palm Springs, Florida in October 1971. The third part contains papers presented at the Louisiana Divisional meeting held in Baton Rouge, Louisiana in February 1971.

The papers presented at the Joint Meeting were edited by Dr. James Irvine, Program Chairman for the June 1971 meeting. Other papers were reviewed by several individuals from Florida and Louisiana.

December 1971

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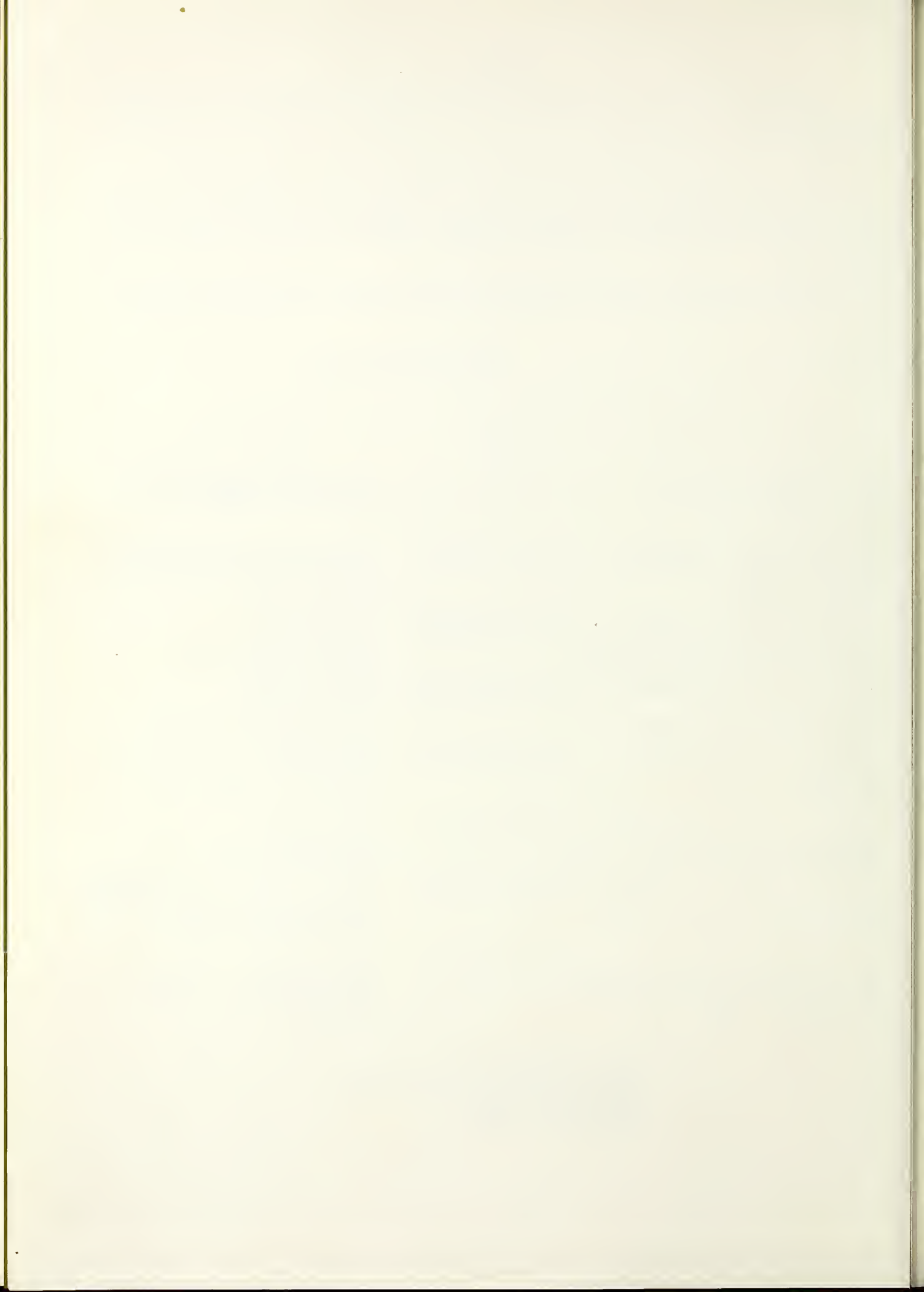


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FALLOW FLOODING: ITS SIGNIFICANCE IN SUGARCANE AGRICULTURE

George Arceneaux
International Research Service

Cultural operations in the production of a farm crop are largely a matter of combating weeds, insects, diseases and other enemies that attack or compete with the plant in cultivation. It is an accepted principle of good farming that complete elimination of the enemy involved is the best defense. In the case of a disease for instance the ideal solution is the cultivation of crop plants so resistant that the disease is completely eliminated as a result of their exclusive use.

Enemies of a crop ordinarily thrive in the environment to which the crop plant is adapted. Control measures such as insecticides and selective herbicides are not ordinarily sufficiently effective to wipe out the pests. Instead, we often face a residual component which, under the influence of biological adaptiveness and genetic segregation takes advantage of the loophole presented by halfway measures. The crop plant competing under increasing disadvantage finally succumbs. Sugarcane agronomists are familiar with the term "varietal failure".

Flooding fields between the customary crop cycles of sugarcane provides an opportunity to impose on the agricultural environment a condition sufficiently drastic to place some of the enemies at an extreme disadvantage. This applies especially to weeds and soil insects. Flooding will also have a significant effect on microbiology of the soil.

Of special significance at this time, is the opportunity offered by flooding to impose control measures that will remove or lessen the need for chemicals in fighting crop pests. But I must hasten to emphasize that fallow flooding is not a brainstorm born out of the present commotion over environmental pollution. On the contrary, it is one of our oldest of agricultural measures. I refer to annual flooding of the Nile Valley which has produced one of the most remarkable agricultures of all times and was in reality the backbone of the Egyptian wealth and civilization.

In the beginning, annual rises of the Nile River simply spilled over the entire valley. Farming followed annually in the wake of the receding water. In time dams were built to slow down the river flow in order to reduce the extent of uncontrolled flooding. Protected areas were irrigated in the usual manner, but with muddy water. Other areas were permitted to be flooded annually (basin irrigation) and cultivated between annual periods of high water. Remarkably enough, in the case of basin irrigation, a crop could be grown after flooding without the use of additional water, thus attesting to the value of organic silt in retaining soil moisture.

But now the whole Egyptian picture has changed. With the new high dam at Aswan, water from the Nile will be impounded in a huge lake extending deep into the Sudan. There the silt will be deposited and crops will be under modern irrigation with essentially clear water. What this will do to Egyptian agriculture and what will happen when the big lake fills up with silt poses interesting problems. The answer will be up to the Russian smart boys who are now running the show in Egypt.

Fallow-flooding as carried on in Guyana is considered especially pertinent because it is imposed by man instead of nature on land devoted to sugarcane culture. In a recent paper Parvatan (8) cites evidence indicating that fallow flooding between cycles of sugarcane has been an agricultural practice in Guyana for nearly 150 years. It is now, and has long been, standard procedure. A practice could not survive so long on such a scale without distinct agricultural merit.

The actual period of flooding varies from 4 to 12 months, as the case may be, but 6 months seems to be representative. In results of studies conducted by Follett-Smith (5) the effect of flooding on field production over the succeeding crop cycle was reported as follows:

<u>Duration of flood fallow period</u>	<u>Tons of sugar per acre (3 crops)</u>	<u>Percent increase attributed to flooding</u>
No flooding	13.1	--
4 months	16.0	22
6 "	17.3	32
12 "	18.3	40

From results of a series of similar studies Evans (4) reported effects of flooding as follows:

<u>Duration of flood- fallow period</u>	<u>Tons of sugar per acre (4 crops)</u>	<u>Percent increase in tons of sugar per acre attributed to flooding</u>
No flooding	16.9	--
4 months	19.8	17
6 "	21.1	25
12 "	22.2	31

An interesting feature of data shown above is the consistent relation between the gain in production of sugar per acre and duration of flooding period up to 12 months. Among beneficial effects cited by the authors are:

- (1) Weed control
- (2) Destruction of soil pest
- (3) Possible eradication of certain disease-causing organisms
- (4) Improvement in soil structure
- (5) Reduction in costs of subsequent cultural operations
- (6) Reduction in quantity of fertilizer required for the plant cane crop.

But an important disadvantage is a delay in starting the next crop cycle. Under tropical conditions cycles of sugarcane crops ordinarily follow in close succession. The intervening period required for renovation includes merely the time needed to destroy the old stubble, prepare a seed bed and plant. Thus, in Guyana, flooding must be done when land could otherwise be growing a cane crop. From a recent economic study Parvatan concluded that the practice is highly justifiable in spite of the incidental reduction in time for actual cropping (8).

In Florida and Louisiana the timing of crop cycles in immediate succession has not been found satisfactory. Instead, it is considered much better to delay replanting until the following fall after ripping out the stubble for renovation. The matter of proper seed bed preparation and timing of the planting are important factors involved. This presents the problem of deciding what to do with the land over the greater part of a year when it is not in cane.

In Florida, the practice has been to allow the land to remain in dry fallow with repeated plowings during spring and summer months to suppress weed growth and prevent seed formation. Within recent years, flooding during the fallow year has been practiced to advantage by some of the growers and the system is rapidly gaining favor. Benefits from flooding reported by Walker (10) are as follows:

- (1) Destruction of wireworms and thus eliminating the need for use of chemical insecticides or repellents at planting time.
- (2) Reduction in prevalence of weeds.
- (3) Reduction in prevalence of certain nematodes.
- (4) Increased production of cane per acre.

Historically the "off-year" rotation with sugarcane in Louisiana was soybeans plowed under for green manure. During the past few decades the practice of growing soybeans has largely given way to fallow plowing during spring and summer months in an attempt to combat the spread of johnsongrass. The change has not been completely effective; in fact johnsongrass is more widespread today and more of a problem than it has ever been.

When fallow plowing was first practiced in Louisiana the essential problem was to eradicate the rhizomes. Now the emphasis has changed to coping with difficulties presented by reinfestation from seedlings. This view is emphasized by L. C. Bourgeois one of the early pioneers in the use of fallow plowing in fighting johnsongrass who reports having had little trouble with seedlings prior to 1940 (3).

Studies have shown that much of the Louisiana cane land is now badly contaminated with viable johnsongrass seed, and a residue invariably remains after the fallow year to rebuild the infestation over the customary 3-year cycle (6) (9).

In a study over the period 1938-1944 inclusive T. J. Arceneaux (1) found the viability of johnsongrass seed produced in southern Louisiana exceedingly low (usually below 1%) in contrast with that of seed produced in North and Central Louisiana where viability typically approached 20%. However in 1943 the viability of johnsongrass seed in southern parishes jumped to a range of 18% to 28%. Commenting on this observation the author cites evidence indicating adverse effects of high atmospheric moisture on production of viable seed in johnsongrass and concludes with the following generalization - "While no definite data relative to climatic and other factors contributing to this exceptional seed development are available these results establish the fact that we may in the cane belt occasionally expect a large crop of viable seed. This situation greatly complicates the eradication problem since land completely rid of rhizomes may, as a result of these seeds, become again rapidly infested."

It has been my observation that the viability of johnsongrass seed now being produced in southern Louisiana is as high or even higher than displayed in 1943.

We have no exact information on viability of johnsongrass seed at the time when the plant first became an important weed pest in Louisiana, but in as much as the plant evolved originally under relatively dry conditions it may well be that humidity could have depressed seed viability to a level approaching zero during the early years of its spread. It would seem that in the meantime there has developed a race of the weed capable of producing extensive quantities of viable seed under our moist conditions. This is just another manifestation of biological adaptiveness under the stress of natural selection.

In fact our very system of control through destruction of rhizomes by fallow plowing may have contributed to the change by forcing an infestation from a new generation of seedlings with each cycle of the sugarcane crop. Ironically enough, this could in a sense be described as a system of plant breeding to produce more and more troublesome forms of johnsongrass.

Fallow flooding during the intercycle year will of course destroy the rhizomes and offers, in addition, the interesting possibility of fighting johnsongrass by killing the seeds as well. Results of studies at the Houma Station indicate that johnsongrass seed will be devitalized from submergence over a period of 3 to 4 months (2). I have repeated these studies in my laboratory at Pass Christian with the same results. Further evidence is available from results of field studies by Hebert (6) who obtained no germination of johnsongrass seed in samples of soil collected from previously flooded rice fields in contrast with millions of viable seeds per acre in samples of soil from nearby fields on which sugarcane had been grown. Observations cited above support results of earlier studies by Maze (7) who showed that some seeds of high starch content will lose their viability from prolonged exposure to anaerobic conditions.

The effect of flooding on johnsongrass seed can be easily demonstrated by the following simple experiment which you can conduct in your own backyard. Take two 50 gallon drums open at the top, place soil in each one up to one foot from the top and plant 1000 seeds of johnsongrass from your field in each. In the first drum keep moisture conditions conducive to germination for a check on seed viability. Keep the second drum filled with water up to the top for a period of 4 months, then drain and maintain a moisture level to promote germination. This will show the effect of flooding on seed viability.

Flooding would be extremely practical in Louisiana where most of the sugarcane is grown along streams with ample supplies of water during spring and summer months. This is especially true of areas along the Mississippi River where water rich in silt could be obtained at times by simple siphoning from the stream.

Gains in field production as reported for Guyana may be interpreted as essentially the effect of interposing an anaerobic environment between periods of sugarcane culture. Sedimentation is not a factor since the water comes from sluggish or stationary sources. Important additional benefits can be expected under Louisiana conditions.

Much of the flooding in Louisiana would normally be done with water from streams carrying a considerable load of silt, hence addition of plant food and possibly improvement in soil texture can be expected as extra benefits. Furthermore, the practice would make it possible to maintain a soil organic matter equilibrium at a much higher level by eliminating losses in humus from repeated plowing during hot weather in the dry fallow schedule.

In the order of importance for Louisiana at this time I would rank above all others the promise offered by fallow flooding in the control of johnsongrass. Besides competing with the crop for plant food and moisture this weed has greatly intensified the mosaic problem by serving as primary host and breeding place for corn aphid the principal vector of the virus.

Flooding as a rotation for sugarcane is of course different from that maintained in rice culture. In the first place the depth of water should be sufficient to maintain good anaerobic conditions throughout the area. In Guyana, fields are flooded to a depth of one foot in the highest spots, which means that some of the areas may be under several feet of water.

Another object is to block off individual areas as large as possible to minimize the cost of setting up levees and to reduce seepage. As an ultimate ideal in a scheme for flooding under Louisiana conditions a plantation of say 2,000 acres should have a 500 acre tract all in one body for flooding each year. It would take a lot of doing to reach that point and in some cases it would mean plowing out stubble that you would ordinarily keep, but operational advantages of single flooding units would more than compensate for minor sacrifices in getting the system under way.

In conclusion, I would like to point out that all experimental evidence available indicates that flooding over a period of 3 to 4 months will destroy rhizomes and detitalize all seeds of johnsongrass in the soil. Increasing the flood period to 6 or 7 months if necessary would be feasible in Louisiana without loss of any cropping time.

I might add parenthetically that biological forms have a way of surviving all sorts of adverse treatments. Our evidence indicates that escapes from the submergence treatment, if any, will be much scarcer than survivors of the fallow plowing operation and therefore easier to contend with. Needless to say that measures to eradicate any surviving residue to guard against a possible race of "flood resistant" johnsongrass will be extremely important.

The promise offered by fallow flooding as a weapon against johnsongrass in Louisiana commands primary interest but with or without johnsongrass the benefits to be expected are extremely attractive especially in the case of growers along the Mississippi River. In a very real sense, you have the opportunity to create, right on your plantation a "mini version" of the Nile Valley with all advantages that History has recorded.

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EFFECTS OF WATER TABLE DEPTHS ON SUGARCANE YIELDS IN LOUISIANA

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ABSTRACT

Sugarcane was grown in plots 18 x 24.2 feet in size on Mhoon clay loam soil for a four-year period, 1967 through 1970, at Baton Rouge. Responses of the sugarcane to a water table constantly maintained at 24, 32, 40, or 48 inches below the soil surface throughout the season were recorded. Cane yields showed no significant difference among the water table treatments; however, yields from the treated plots were approximately 60 percent more than yields from check plots. Moreover, cane yields from the treated plots were consistently above 35 net tons per acre through third stubble. This is highly significant since cane yields usually decrease to such a low level after second stubble that third stubble crops are not normally grown in Louisiana.

All four water table treatments increased vegetative growth over that from check plots but decreased the sucrose of the cane's juice; however, the higher cane yields from the treated plots more than compensated for the reduced sucrose and the sugar yield per acre was consequently significantly increased by the water table treatments.

INTRODUCTION

Sugarcane, like many other plants, requires a proper balance of water, air, nutrients, and sunlight for maximum growth. If any of these requirements is less than optimum, growth may be decreased accordingly. In the sugarcane area of Louisiana, natural conditions do not always provide an adequate balance of these growth requirements to ensure maximum plant growth. Through management practices, cane farmers have made progress towards obtaining this ideal balance. They use fertilizer to provide a high level of nutrition; land grading, land smoothing, and ditching practices to provide surface drainage; and high seed beds to provide internal soil drainage and aeration around the roots. Very little has been done, however, to provide cane with supplemental water during periods of drought.

In 1970 Carter, Elkins, and Floyd reported an experiment where controlled water tables greatly increased cane yields.³ This paper reports additional data from this experiment and shows that water table control also increased sugarcane longevity.

PROCEDURE

Concrete-bordered plots 0.01 acre in size were established on Mhoon clay loam soil at Baton Rouge on Louisiana State University's Ben Hur research farm. The concrete borders began 1 foot under the soil surface and continued downward 4 1/2 feet. Each plot was equipped with two tile drains connected by pipe to a sump containing a water supply, valves, and a drain for maintaining the water level at any desired elevation from near the soil surface to 5 feet deep. The water elevation in each sump was adjusted to attain the desired water table elevation in the plots.

The plots were planted in the fall of 1966 to CP 55-30 variety sugarcane in rows spaced 6 feet apart. Four water table treatments, 24, 32, 40, and 48 inches in depth, were imposed on 12 plots in the spring of 1967 to test the hypothesis that the intermediate water tables would provide a more favorable soil air-water balance and that cane yields from these treatments would be higher than those from the shallower or deeper water tables. Cane yields from a nearby site were used as a check where conditions were similar to those in these plots except for the water table control.

Conventional methods of cane culture were used except for water table control and hand weeding to control Johnsongrass. In the spring of 1967 and 1968, one application of fertilizer was made at rates of 100 lbs. N, 80 lbs. P₂O₅, and 80 lbs. K₂O per acre. In 1969 and 1970 these rates were doubled, with half of the nitrogen fertilizer applied in the spring and the other half applied in the summer because the color of the cane leaves indicated a plant nutrient deficiency in 1968 where the water tables were controlled.

Cane was harvested during the first two weeks of November each year. After burning the leaves, the cane stalks were weighed for yields. Ten stalk samples were taken from each plot and analyzed at L.S.U.'s Botany-Plant Pathology Sugar Mill for sucrose, purity, and Brix density measure.

³Carter, C. E., Elkins, C. B., and Floyd, Jesse M. Water Management in Sugarcane Production. American Society of Sugar Cane Technologists Proceedings. 17:10-24, 1970.

RESULTS AND DISCUSSION

Average yields recorded from the four water table treatments in plant cane (1967), first ratoon (1968), second ratoon (1969), and third ratoon (1970) were 36, 32, 75, and 54 percent greater, respectively, than those recorded from plots without water table control (Table 1). Such positive yield responses show that controlled water tables caused very favorable conditions in the soil for cane growth. Water, air, and plant nutrients apparently approached a more favorable balance in the treated plots than in plots without water table control.

Yield differences were small between the controlled water table treatments. A tendency for increased yields with increased depth to the water tables was noted, however, the difference was not significant. This trend was most pronounced in 1970 when cane yields increased 2 tons per acre for each 8-inch increment to the water table. The highest yield recorded, 50.3 net tons per acre in 1967, was from plots with constant water tables at 40 inches below the soil surface. The lowest yield, 35.8 net tons per acre in 1970, was from plots with a constant water table at 24 inches.

Constant water table treatments increased the number of high yielding crops harvested from one planting. Normally, yields in Louisiana decrease to such a low level after the second ratoon crop that additional ratoon crops are not grown. Yields from third ratoon in this study however, averaged 39 tons of cane and 3.1 tons of sugar per acre. This was 41 percent more sugar than was recorded from check plots. The highest state (Louisiana) average yields ever recorded were 29 tons of cane and 2.7 tons of sugar per acre in 1963.

The increase in cane yields and longevity is attributed mainly to drainage and irrigation. A constant water table provides both - drainage above the water table and irrigation at the water table. The water level control system used in this study automatically replenished the supply of water in the soil when the natural water level decreased through evaporation, transpiration, and deep percolation. The system also automatically drained excess water from the plots that was caused by either rainfall or a rise in the natural water table. This drainage feature was very important since it prevented the soil from becoming waterlogged around the seed cane pieces during the winter and early spring when the natural water table rose almost to the soil surface. Maintaining the water table below the seed cane apparently enhanced aeration of the seed cane environment and decreased the rate of decay and deterioration of the seed pieces. This resulted in a higher plant population in the treated plots as compared with the uncontrolled plots. For example, the plant population of the third ratoon treated plots at harvest in 1970 ranged from 34,000 to 36,333 plants per acre while the check plots had only 28,000 plants per acre.

Maintaining the water table 24 inches or more below the soil surface also provided cane plants in the treated plots with an early growth advantage over those in the untreated area. Average height of 10 randomly selected plants from the two extreme treatments, i.e., 24- and 48-inch water tables, in July 30, 1970, was 58.5 and 58.4 inches respectively, while the check plot was only 34.8 inches. This difference is attributed to a warmer soil earlier in the spring due to improved drainage, and to a well aerated, non waterlogged, root zone.

Cane yields from the treated plots were 13 percent more in 1969 than in 1968. This increase was due mainly to the extra fertilizer added in 1969. There were indications in the 1967 and 1968 cane crops that the fertility level might have limited cane yields from the water controlled plots.

Sugar yields from the water controlled plots ranged from 3.0 to 4.7 tons per acre during this 4-year experiment. The four treatments averaged 4.4 tons per acre for three consecutive years and 3.1 tons per acre from the third ratoon (Table 1). This was 29, 19, 38, and 41 percent more sugar per acre from the plant cane year, first ratoon, second ratoon, and third ratoon, respectively, than was recorded from the check plots. Average Louisiana state sugar yields usually range from 2 to 2.5 tons per acre.

Sucrose content of the cane juice from the treated plots was lower in every case than that from the check plots. Data in Table 1 show a tendency for a decrease in sucrose percentage with increasing cane yields. The higher cane yields, however, more than compensated for the lower sucrose, and sugar yield per acre was more from the treated plots. Sucrose in 1970 was relatively low. This is attributed partially to adverse weather conditions, including rain and high winds late in the growing season that downed and uprooted much of the cane.

Constant water table treatments in sugarcane in Louisiana show promising economic benefits. Each ton increase in the state's average cane yield boosts cane farmers' gross income \$3,000,000 annually, assuming \$10 per ton on 300,000 acres of cane. Increasing the number of crops harvested from one planting also increases income by distributing the planting cost of approximately \$100 per acre over four or more years instead of the normal three. Costs for installing water table control practices (estimated between \$100 and \$200 per acre) would be small on a per crop basis since it could be amortized over 15 or 20 years.

SUMMARY

Controlled water tables increased sugarcane yields and increased the number of high yielding crops harvested from one planting from the normal three to four. Cane yields showed no significant

difference between the water table depths of 24 to 48 inches. Yields from the treated plots were 32 to 75 percent more than yields from plots without water table control.

All four water table treatments increased vegetation growth over that from check plots but decreased the sucrose content of the cane's juice. However, the higher cane yields from the treated plots more than compensated for the reduced sucrose, and the sugar yield per acre was increased significantly by the water table treatments.

TABLE 1. Yield and Juice Data from Constant Water Table Study

Year	Water Table Treatment (Inches)	YIELD		JUICE	
		Cane (T/A)	Sugar (T/A)	Sucrose (Percent)	Brix (Degrees)
1967	24	45.7	4.4	13.6	17.4
	32	49.7	4.7	13.4	17.3
	40	50.3	4.4	12.5	16.4
	48	47.0	4.2	12.8	16.7
	Average	48.2	4.4	13.1	17.0
	Check	35.4	3.4	13.7	16.7
1968	24	40.0	4.2	14.7	17.8
	32	40.6	4.3	14.8	17.8
	40	41.2	4.4	15.0	18.1
	48	42.8	4.5	14.7	17.8
	Average	41.2	4.4	14.8	17.9
	Check	31.1	3.7	16.3	18.8
1969	24	43.8	4.3	13.7	16.7
	32	46.7	4.4	13.5	16.5
	40	46.6	4.4	13.5	16.8
	48	48.9	4.7	13.3	16.5
	Average	46.5	4.4	13.5	16.6
	Check	26.6	3.2	16.3	18.5
1970	24	35.8	3.0	12.4	16.0
	32	38.1	3.1	12.0	15.8
	40	40.1	3.2	11.9	15.8
	48	42.0	3.1	11.2	15.2
	Average	39.0	3.1	11.9	15.7
	Check	25.4	2.2	12.5	16.2

RELATIONSHIP OF SOIL pH TO
SUGARCANE RESPONSES ON
EVERGLADES PEAT 1/

G. J. Gascho and C. E. Freeman 2/

ABSTRACT

One pot culture and two field experiments were conducted with Everglades peat soil in order to determine the effects of soil pH and incorporations of limes, slags, sulfur, and canal-bank limestone on sugarcane tonnage and sugar yield.

Eleven to 15 tons per acre of broadcast dolomitic limestone were required to raise the soil pH from 5.5 to 6.5. Broadcast applications of sulfur were very ineffective for lowering the pH of organic soil over a 3 year period. Soil pH decreased from 7.2 at 60 feet from a limestone road to 5.7 at 300 feet.

Sugarcane tonnage and sugar yield in the field were not significantly affected by a range of soil pH from 5.2 to 7.2 nor by a wide range of soil calcium and magnesium levels and ratios. In pot culture a slag containing 18.6% silicon increased the weight of immature sugarcane over check, limes and other slags. Regression analyses indicated that silicon in the plant and in the soil were better associated with the weight increase than were the other elements evaluated. The effect of the siliceous slag appeared to be indirect.

Sugarcane grows well at a wide range of pH conditions throughout several areas of the world. Increases in sugarcane tonnage due to lime application have been reported by many researchers (6, 12, 13, 16, 18). In many instances increased tonnage was accompanied by a decrease in percent sucrose therefore making the utility of liming doubtful (6, 7, 14, 16, 18). Increases in yield of sugar per acre from liming have largely been limited to acid podzolic and lateritic soils containing kaolin and illite clay minerals with abundant quantities of Fe and Al oxides (9, 12). Some increases are likely due to improved Ca nutrition (9).

Presently, the application of 500 pounds per acre of S in the furrow before planting where the pH is 6.5 or higher is recommended for plant cane on the organic soils in South Florida (8). The purpose of this S is to increase the availability of micronutrients, particularly Mn in a small volume of the soil. The effect of this application on the pH of the soil as a whole is negligible. In earlier experiments favorable growth responses of sugarcane due to application of Mn without S were not noted when the pH was extremely high (1).

A preliminary investigation of the relationship of soil pH to sugarcane response on the organic soils in South Florida (11) indicated that better growth was obtained when the soil pH was greater than 6 than when the pH was less than 6. Improved growth was reported for both greenhouse and field experiments but no cane or sugar yield increases were reported for experimental sugarcane plots.

MATERIALS AND METHODS

Broadcast lime and sulfur

Plots of 0.02 acre were arranged in a randomized complete block design with five replications on a virgin Everglades peat soil (17). Broadcast applications included 5, 10, 15 and 20 tons per acre of dolomitic limestone and 0.5, 1.0 and 1.5 tons per acre of S. These amendments were manually spread on the plots and were disced in to a depth of 6 to 8 inches. Three hundred pounds of 0-0-50 fertilizer with 0.75% CuO, 2.0% ZnO, 0.25% FeO and 0.75% B₂O₃ was applied in the furrow prior to planting variety Cl. 41-223. Each of two ratoons was fertilized with 300 pounds per acre of 0-0-50. Plots were harvested experimentally as first and second ratoon. Ten-stalk samples were collected for juice analyses of brix and pol. Soil samples were taken by probe to a depth of 6 inches, 2.5 and 3.1 years after the materials were broadcast. Soil analyses were made by the methods in use at the Agriculture Research and Education Center, Belle Glade, (15). Analysis of variance and Duncan's multiple range test were used to facilitate the interpretation of data for all experiments.

Canal bank limestone incorporation

An experiment designed to study P and K levels on an Everglades peat soil was arranged in a randomized complete block design with the blocks parallel to a limestone road. Plots were 0.02 acre and

1/ Florida Agricultural Experiment Station Journal Series Number 3969.

2/ University of Florida, IFAS, Agricultural Research and Education Center, Belle Glade.

were planted to variety Cl. 41-223. Growth measurements to the top visible dewlap (TVD) were made twice during the plant crop, soil samples were collected to a depth of 10 to 12 inches and TVD leaf blades were collected in both the plant and first ratoon crops. Soil samples were analyzed as above, leaf tissue was analyzed for P colorimetrically, for K spectrophotometrically, for Ca and Mg titrimetrically and for Cu, Zn, Fe and Mn by atomic absorption. The experiment was harvested as plant and first ratoon crops and samples were collected for juice analyses as above.

Limes and slags in the greenhouse

A factorial randomized complete block experiment with three rates of three slags and two liming materials in four replications was conducted in the greenhouse for 5 months and then moved outside. Limes and slags used, their mineral contents and neutralization values are listed in Table 1. These minerals together with 1200 pounds per acre, on a weight basis, of 0-10-20, were mixed with virgin Everglades peat soil. Two single-eye seed pieces of variety C.P. 59-73 were planted in 3 gal. plastic tubs. In addition to the above fertilization all tubs were watered weekly with a dilute solution of complete fertilizer containing a full complement of micronutrients. Soil samples were collected at 1 and 9 months (harvest). At 9 months, tops of the three largest stalks were collected for analyses and all above ground material was weighed after thoroughly drying at 70°C. Soil and tissue analyses were conducted as in the previous experiments.

RESULTS AND DISCUSSION

Broadcast lime and sulfur

Soil pH changes due to liming are given in Figure 1. Soil samples collected at 2.5 and 3.1 years after dolomite application indicated a curvilinear pH response, with 11 to 15 tons of dolomite required to raise the pH from 5.5 to 6.5. Twenty tons of dolomite raised the pH less than 0.1 unit more than 15 tons, indicating the soil pH was highly buffered in the upper portion of the range studied. Differences between the two sampling dates were greater for the high application rates indicating that some of the dolomite was still neutralizing acidity after 2.5 years in the soil.

Figure 2 shows a nearly linear decrease of soil pH with increasing amounts of broadcast S. However, one ton per acre of S decreased soil pH only about 0.2 units in the 2.5 to 3.1 year period considered. A comparison of the two sampling dates indicate that broadcast S was not active in decreasing soil pH after 2.5 years in the soil.

Soil test data (Table 2) indicate variable results for P and no significant differences for K. Soil Ca and Mg increased with rates of dolomite applied. Calcium to Mg ratios varied from 1.65 to 3.32.

No differences in tons of cane per acre (TCA) or tons of sugar per acre (TSA) were recorded among check, dolomite and S treatments for either the first or second ratoon crop. More pounds of sugar per ton of cane were produced in the second ratoon from plots where dolomite was applied at rates of 10 to 20 tons per acre than where S was applied. However, none of the treatments in either year were significantly higher than the check in TCA, pounds of sugar per ton of cane, or TSA.

Even though this experiment created a wide range of soil Ca and Mg levels and ratios, sugarcane tonnage and sugar yield were affected very little in the pH range 5.25 to 6.85. These results agree well with field applications of Ca CO₃ limestone at rates up to 32 tons per acre.*

Canal bank limestone incorporation

With increasing distance from a limestone road and decreasing soil pH (Figure 3) sugarcane yield and quality were not affected in a range from pH 5.7 to 7.2 (Table 3). A wide range of P and K soil levels were present in each pH group. Mineral analyses of tissue samples from the TVD leaf blades showed that Mn concentration increased from 13 to 52 ppm with distance from the road and decreasing pH. Thirteen ppm is not considered too low for maximum sugarcane growth and development (4) and no yield reduction was noted. Higher pH would likely have further reduced Mn leaf blade content and likely caused a deficiency. Phosphorus tissue levels decreased with pH increases but again were in the range expected for good growth. No significant differences were found for tissue K, Cu, Zn and Fe.

Limes and slags in pot culture

Calcium carbonate limestone was the most effective amendment for increasing soil pH in 3 gal. plastic tubs. Dolomitic limestone and TVA slag were approximately equal in effect, while Fairfield and Wylam slags were less effective (Table 4). In general, soil P decreased and soil Ca, Mg and Si increased with application of an amendment. Very high soil P resulted from applications of Fairfield and Wylam slags. High soil levels of Si resulted from application of TVA slag (18.6% Si). Soil nutrient levels (except K at 1 month) were all adequate for good sugarcane growth. The P levels however were judged too high for high sucrose production if the cane had been allowed to mature. Plant tissue P and Si were affected in the same manner as soil levels by the treatments (Table 5). Plant Mn decreased with increased rates of treatments. Tissue Cu, Zn, and Fe levels showed no trends with treatments, but were adequate.

* Andreis and Gascho, unpublished data.

Regression analysis indicated a high linear correlation ($r=.955$) between rate of TVA slag, in the range of 0 to 10 tons per acre, and dry weight of immature canes (Figure 4). Since TVA slag contained 18.6% Si and increased soil and plant levels there was a high correlation between the concentration of Si in the plant and dry weight of cane ($r=.846$). These were the highest r values obtained in a search to explain the increased yield with TVA slag.

An immediate conclusion that Si is a necessary nutrient and was responsible for increased yield merits examination. Sugarcane tonnages in Florida are highest close to the shores of Lake Okeechobee. Okeechobee muck soils near the lake average 35.82% SiO_2 while Everglades peat soils average 4.18% SiO_2 (10). It is tempting to try to relate sugarcane tonnage with soil silicon content especially in light of work in Hawaii (2, 5) showing increased sugarcane tonnage and sugar yields from applications of TVA slag to soils low in Si. Greatest response to TVA slag in Hawaii has been on acid soils high in Al and Fe oxides. Ayres (2) concluded that there is a level of available or soil extractable soil Si below which satisfactory growth of sugarcane will not be obtained regardless of supplies of macro- and micro-nutrients to which it has access. However, precise work in liquid nutriculture using chemically pure reagents has shown little or no specific need for Si.* It would appear that Si or silicates in these experiments acted indirectly to increase yields. No clues to the mechanism of increased dry weight were found in the data and the answer is undoubtedly complex. Further work is in progress on this phase.

SUMMARY

Field broadcast applications of dolomitic limestone indicated that 11 to 15 tons were required to raise the pH of Everglades peat from 5.5 to 6.5. Broadcast applications of S were of little use for lowering the pH of this soil.

In two field experiments sugarcane tonnage and sugar yields were not changed by soil pH ranging from 5.2 to 7.2 or by a wide range of soil Ca and Mg levels and ratios associated with incorporations of limes, slags, S, or canal bank limestone. It does not appear that pH alteration of Everglades peat soil (the dominant soil type on which sugarcane is grown in Florida) is practical or economical for sugarcane production. The results presented here do not represent all of the soils of the Florida sugarcane industry and results obtained on other soils, particularly on sandy soils, may be different.

A pot culture experiment showed that soil incorporation of a slag high in Si (18.6%) increased the weight of young sugarcane over check and over incorporations of limes and other slags. This effect was not due to pH alteration. Regression analyses of soil and plant tissue results and dry weights of these plants indicated that there was a high linear correlation between tissue Si and dry weight. It is unlikely that Si is acting strictly as plant nutrient since other experiments have shown little or no requirement for this element.

ACKNOWLEDGMENTS

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Table 1. Mineral contents (%) and neutralizing values of 3 slags.

Slag	Ca	Mg	Mn	Fe	S	B	Cu	Mo	Zn	Si	P ₂ O ₅	K ₂ O	Approximate Neutralizing value
TVA	33.0	trace	0.023	0.07	0.2	trace	0.0	0.01	trace	18.6	1	0.2	50
Fairfield	18.0	4.8	2.3	NV ^{1/}	NV	NV	NV	NV	NV	5.6	3	NV	60
Wylam	21.5	1.8	1.5	15.5	NV	NV	NV	NV	NV	6.15	6	NV	60

^{1/} NV - no value given by manufacturer.

Table 2. Soil test data, sugarcane tonnage, and sugar yield as affected by lime and sulfur applications

Tons/acre	2.5 years after treatment				lb/acre soil test ^{1/}			
	P	K	Ca	Mg	P	K	Ca	Mg
	3.1 years after treatment							
20 dolomite	6.6 ^{ab2/} _b	181	4867 ^a _b	2956 ^a _a	6.0	107	5765 ^a _a	2000 ^a _a
15	4.8 ^b _b	111	4497 ^b _b	2720 ^b _b	3.8	89	5000 ^b _b	2000 ^a _a
10	4.2 ^b _b	93	3455 ^c _c	1655 ^b _b	4.6	84	4126 ^c _c	1863 ^a _a
5	8.2 ^{ab} _b	151	2835 ^d _d	1211 ^c _c	6.2	91	3167 ^d _d	1422 ^b _b
0	5.2 ^b _b	100	2405 ^e _e	763 ^d _d	4.8	78	2385 ^e _e	783 ^c _c
0.5 sulfur	7.0 ^{ab} _{ab}	173	2385 ^e _e	787 ^d _d	6.2	95	2431 ^e _e	777 ^c _c
1.0	7.0 ^{ab} _{ab}	127	2205 ^e _e	720 ^d _d	5.8	69	2357 ^e _e	824 ^c _c
1.5	9.2 ^a _a	122	2015 ^e _e	616 ^d _d	7.2	77	2067 ^e _e	624 ^c _c
	**	NS ^{3/}	** ^{4/}	**	NS	NS	**	**
1st ratoon								
Tons/acre								
	TCA	lb sugar ton cane		TSA	TCA	lb sugar ton cane		TSA
20 dolomite	55.0	203		5.59	41.8	180 ^{a/} _{a/}		3.73
15	56.0	203		5.69	41.6	183 ^{a/} _{a/}		3.88
10	56.4	200		5.65	45.5	180 ^{ab/} _{ab/}		3.70
5	56.7	202		5.73	38.9	176 ^{ab/} _{ab/}		3.45
0	56.2	198		5.58	39.0	176 ^{ab/} _{ab/}		3.06
0.5 sulfur	54.0	199		5.38	40.8	168 ^{b/} _{b/}		3.40
1.0	60.5	196		5.95	40.6	167 ^{b/} _{b/}		3.58
1.5	58.0	202		5.86	39.3	169 ^{b/} _{b/}		3.41
	NS	NS		NS	NS	**		NS

^{1/} methods of Agr. Res. Ed. Center, Belle Glade.
^{2/} values not followed by common letter are significantly different at the 5% level.
^{3/} NS - no statistically significant difference at the 5% level.
^{4/} differences significant at the 1% level.

Table 3. Soil pH, sugarcane tonnage, and sugar yield in canal bank limestone experiment.

Soil pH	plant cane			1st ratoon		
	TCA	<u>lb sugar</u> ton cane	TSA	TCA	<u>lb sugar</u> ton cane	TSA
7.2 ^a <u>1/</u>	49.5	217	5.36	34.0	267	4.56
6.4 ^b	47.7	215	5.11	33.5	273 ¹	4.60
6.0 ^c	49.7	214	5.31	35.3	271	4.82
5.8 ^{cd}	49.6	210	5.21	34.7	271	4.69
5.7 ^d	49.7	204	5.30	36.3	282	5.11
<u>**2/</u>	<u>NS^{3/}</u>	NS	NS	NS	NS	NS

1/ abcd - values not followed by a common letter are significantly different at the 5% level.

2/ - differences significant at the 1% level.

3/ NS - no statistically significant difference at the 5% level.

Table 4. Soil analyses in pots as affected by application of limes and slags at 3 rates.

Lime of Slag	Soil analyses at 1 month						Soil analyses at 9 months					
	lb/acre						lb/acre					
	pH	P	K	Ca	Mg	ppm	pH	P	K	Ca	Mg	Si
Ca Co ₃	6.45 ^a	5 ^d	15 ^a	8227 ^a	2665 ^a	7 ^d	6.61 ^a	30 ^b	188	5932 ^a	1322 ^b	7 ^d
Dolomite	5.66 ^b	14 ^c	13 ^{ab}	4216 ^b	2933 ^b	7 ^d	6.03 ^b	37 ^b	48	3464 ^b	2244 ^a	7 ^d
TVA	5.65 ^{bc}	14 ^c	15 ^a	4070 ^b	1461 ^b	31 ^a	6.12 ^c	39 ^b	165	3843 ^b	1088 ^b	31 ^a
Fairfield	5.52 ^c	30 ^a	13 ^{ab}	3932 ^b	1904 ^b	18 ^c	5.78 ^c	41 ^b	147	3571 ^b	1227 ^b	18 ^c
Wylam	5.61	40	12	4104	1734	14	5.80 ^c	77 ^a	151	3318	1047 ^b	14 ^c
	**2/	**	*3/	**	**	**	**	**	NS4/	**	**	**
Rate (tons/acre)												
5	5.45 ^c	22 ^a	12 ^b	3755 ^b	1472 ^c	10 ^c	5.68 ^c	57 ^a	158	3079 ^c	970 ^b	10 ^c
10	5.70 ^b	22 ^a	13 ^b	4325 ^b	1934 ^b	13 ^b	5.96 ^b	41 ^b	146	3618 ^b	1290 ^b	13 ^b
20	6.10 ^a	18 ^b	15 ^a	6649 ^a	3013 ^a	23 ^a	6.56 ^a	37 ^b	175	5379 ^a	1896 ^a	23 ^a
	**	**	**	**	**	**	**	**	NS	**	**	**
Check vs. others												
check	5.02 ^b	20	10 ^b	2397 ^b	936 ^b	6 ^b	5.09 ^b	66 ^a	146	1856 ^b	632 ^b	6 ^b
others	5.78 ^a	21	13 ^a	4910 ^a	2139 ^a	15 ^a	6.07 ^a	45	160	4025 ^a	1835 ^a	15 ^a
	**	NS	**	**	**	**	**	**	NS	**	**	**

1/ values followed by a common letter are not significantly different at the 5% level.
 2/ ** differences significant at 1% level.
 3/ * differences significant at 5% level.
 4/ NS - no significant differences at the 5% level.

Table 5. Yield of young sugarcane and mineral analyses of leaf blades as affected by limes and slags applied at 3 rates.

Lime or slag	% in tissue		ppm in tissue					Dry weight (g)
	Si	P	Cu	Zn	Mn	Fe		
Ca Co ₃	.185 ^c 1/	.180 ^c	12	30	38 ^b	64	650 ^c	
Dolomite	.156 ^c	.239 ^b	11	21	62 ^b	58	624 ^c	
TVA	.748 ^a	.236 ^b	14	34	58 ^b	61	803 ^a	
Fairfield	.389 ^b	.248 ^{ab}	13	33	183 ^a	65	729 ^b	
Wylam	.328	.281 ^a	12	29	167 ^a	63	669 ^{bc}	
	**	**	NS	NS	**	NS	**	
Rate (tons/acre)								
5	.231 ^c	.270 ^a	13	34 ^a	132 ^a	62	701	
10	.314 ^b	.233 ^b	12	29 ^b	110 ^b	62	714	
20	.538 ^a	.207 ^c	13	31 ^{ab}	63 ^c	65	671	
	**	**	NS	*	**	NS	NS	
Check vs. others								
check	.136 ^b	.325	12	40 ^a	119	71	621	
others	.361 ^a	.237	12	31 ^b	102	62	695	
	**	NS	NS	**	NS	NS	NS	

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1/ values followed by a common letter are not significantly different at the 5% level.
 2/ NS - no significant differences at the 5% level.
 3/ * differences significant at 5% level.
 4/ ** differences significant at 1% level.

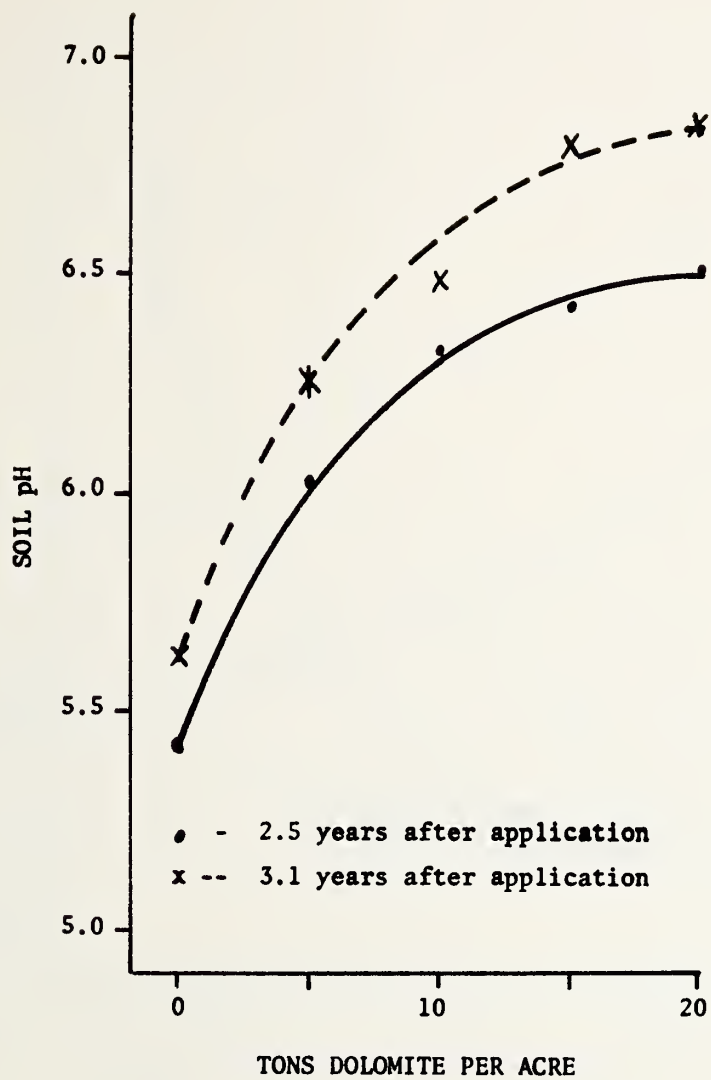


Figure 1. Effect of broadcast dolomite on the pH of Everglades peat

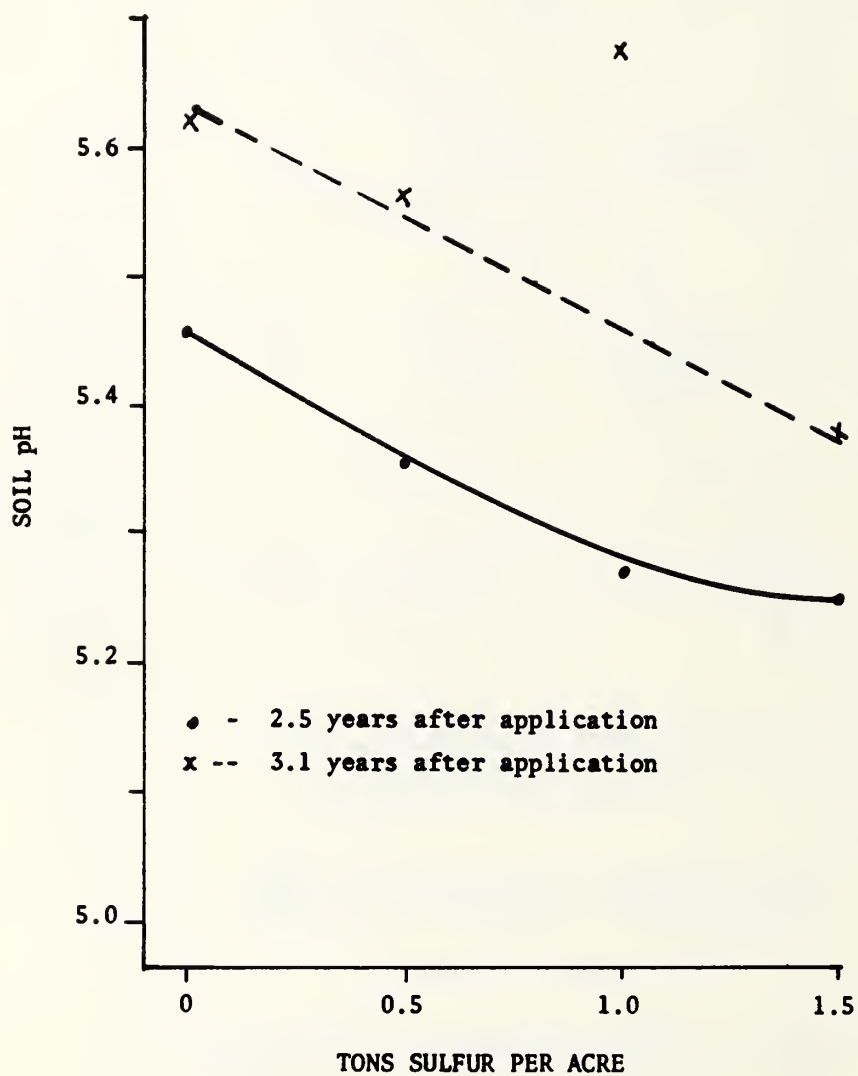


Figure 2. Effect of broadcast sulfur on the pH of Everglades peat

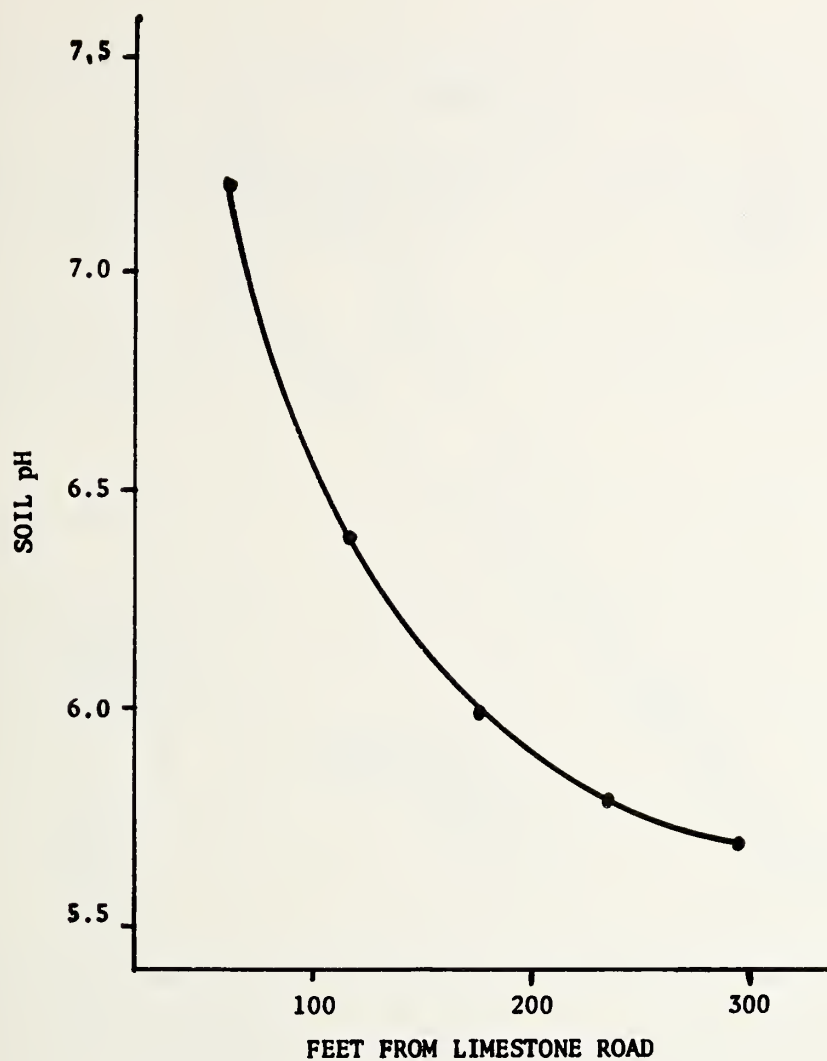


Figure 3. Relationship of the pH of Everglades peat to distance from a limestone road

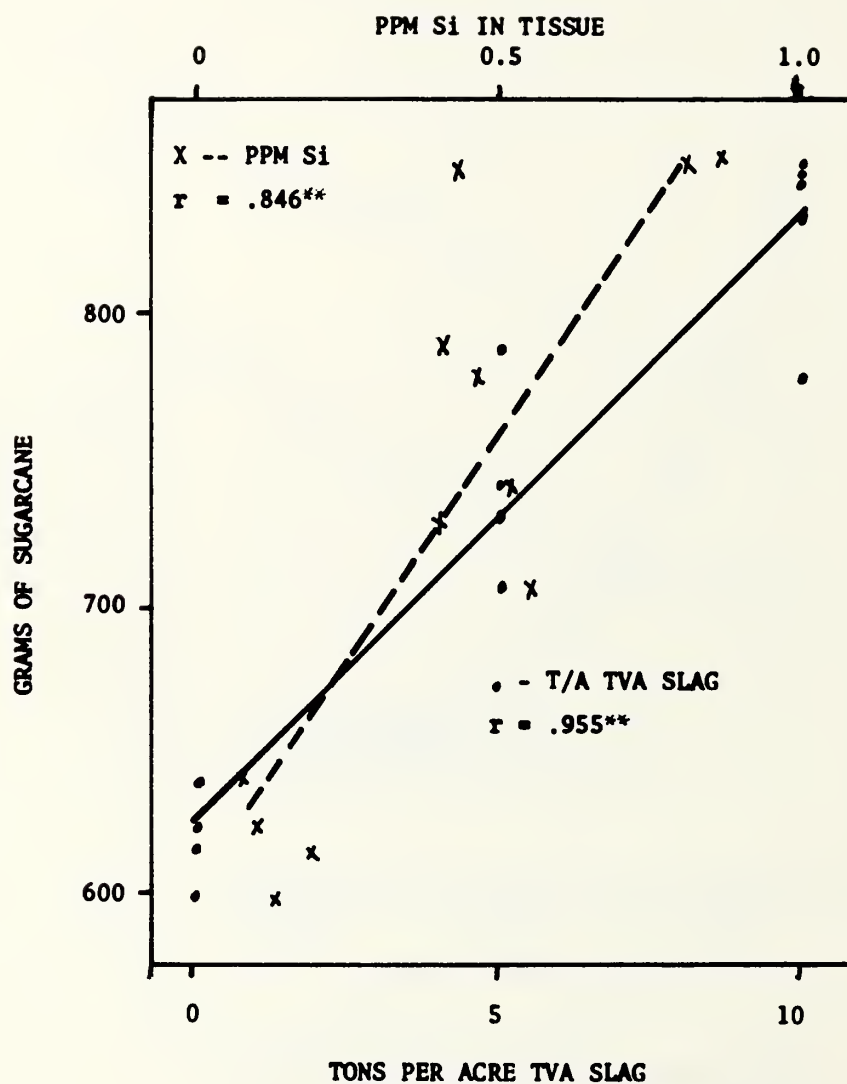


Figure 4. Effect of TVA siliceous slag on Si concentration in leaf blade tissue and weight of young sugarcane

THE RELATIONSHIP OF P, K, Ca AND Mg EXTRACTABLE
FROM SOILS TO P, K, Ca AND Mg CONTENTS OF SUGARCANE LEAF BLADES

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ABSTRACT

Soil and leaf-blade samples from 28 field experiments were analyzed to determine the relationships of soil-test values for P, K, Ca and Mg to the amounts of the nutrients in leaf blades of sugarcane.

The relationship between extractable soil P(X) and leaf P(Y) was shown in the equation, $Y = 0.1697 + 0.000069X$. The relationship between extractable soil K(X) and leaf K(Y) was shown in the equation, $Y = 0.7520 + 0.002355X$. The regression coefficients were highly significant. The correlations between extractable P and leaf P and between extractable K and leaf K were similar in magnitude to corresponding correlations found in previous work between extractable P and yield response to fertilizers containing P and between extractable K and yield response to fertilizer K.

The lowest Ca and Mg contents found in leaf blades were considerably higher than levels considered to be critical, and the ranges in Ca and Mg contents were within ranges considered to be normal. It was concluded that additions of Ca and Mg as plant nutrients generally are not needed for sugarcane in Louisiana.

INTRODUCTION

Standard leaf-P and leaf-K contents for sugarcane in Louisiana have been proposed as shown in Table 1 (7).

TABLE 1. Standard leaf-nutrient contents for sugarcane in Louisiana

Nutritional status of the crop	P	K
	%	%
Very low	< 0.14	< 1.00
Low	0.14-0.18	1.00-1.25
Medium	0.18-0.22	1.25-1.75
High	0.22-0.26	1.75-2.00
Very high	> 0.26	> 2.00

Significant correlations have been found in Louisiana between extractable soil P and yield response by sugarcane to fertilizers containing P (2, 6) and between extractable soil K and yield response to fertilizer K (11).

Evans (5) reported that critical values for Ca and Mg in sugarcane leaf blades (top visible dew-lap or TVD) are 0.13 to 0.15 and 0.06 to 0.08 percent-dry-weight basis, respectively. He reported that normal ranges for Ca and Mg in leaf blades are 0.16 to 0.50 and 0.08 to 0.35 percent-dry-weight basis, respectively (4).

The Ca and Mg contents of most soils cropped to sugarcane in Louisiana are generally high. Agricultural limestone has been recommended for application to soils cropped to sugarcane when the soil pH was below 6.0. The yield responses obtained when agricultural limestone was applied (3) were apparently due to a combination of general beneficial effects which include increasing the availability of P, increasing the rate of mineralization of N, and improving the physical condition of the soil.

The purpose of this study was to determine the relationship of soil test values for selected plant nutrients and their absorption, as reflected by amounts of the nutrients in leaf blades of sugarcane.

Table 2. The relationship of plant nutrients extractable from soil, soil pH and plant-nutrient contents of leaf blades of sugarcane.

Soil type	Plantation	Year	Ext. P	Leaf P	Ext. K	Leaf K	Ext. Ca	Leaf Ca	Ext. Mg	Leaf Mg	pH
			ppm	%	ppm	%	ppm	%	ppm	%	
Mississippi alluvial soils											
Commerce sil	Myrtle Grove	1965	308	0.196	100	1.12	1791	0.468	321	0.215	5.8
Commerce sil	Myrtle Grove	1966	854	0.225	111	1.25	3091	0.412	425	0.163	6.7
Commerce sil	Evan Hall	1970	324	0.161	121	0.93	1892	0.434	430	0.249	6.5
Mhoon sil	Little Texas	1966	216	0.192	80	0.84	1800	0.463	495	0.225	6.4
Mhoon sil	Star	1967	228	0.217	141	1.29	2109	0.326	369	0.259	6.4
Mhoon sil	Upper Ten	1968	472	0.218	104	1.17	2134	0.342	593	0.223	5.2
Mhoon sil	Georgia	1969	247	0.193	102	1.09	2828	0.437	472	0.220	6.7
Mhoon sil	St. James	1969	222	0.164	139	0.90	2898	0.470	689	0.288	6.1
Mhoon sil	Georgia	1969	255	0.193	98	0.98	2480	0.447	462	0.215	6.6
Mhoon sil	Laurel Grove	1966	271	0.215	151	1.22	3462	0.310	713	0.187	6.1
Mhoon sil	Laurel Grove	1968	655	0.195	141	1.48	3904	0.385	836	0.171	6.2
Mhoon sil	Evan Hall	1969	249	0.174	220	1.09	5006	0.253	972	0.153	6.1
Mhoon sil	Uncle Sam	1970	286	0.166	286	1.53	4149	0.304	1119	0.171	6.8
Mhoon sil	St. James	1970	414	0.201	251	1.21	3299	0.318	808	0.185	5.6
Sharkey c	Little Texas	1967	227	0.230	205	1.20	5942	0.374	1171	0.267	7.0
Sharkey c	Evergreen	1968	220	0.172	328	1.40	3536	0.359	792	0.128	5.9
Sharkey c	Evan Hall	1968	246	0.206	352	1.56	4533	0.381	1196	0.129	6.0
Pleistocene terrace soils											
Jeanerette sil	Simoneaux	1968	99	0.194	109	1.07	1811	0.339	568	0.255	5.8
Jeanerette sil	Kilgore	1969	26	0.117	71	0.71	2261	0.315	607	0.250	5.5
Jeanerette sil	Simoneaux	1969	27	0.179	82	1.17	1810	0.482	400	0.263	7.0
Jeanerette sil	Lamaire	1969	23	0.164	55	0.39	1948	0.423	291	0.331	6.0
Baldwin sil	O'Neil	1966	35	0.147	191	1.46	2757	0.350	526	0.210	5.0
Baldwin sil	O'Neil	1967	38	0.158	180	1.10	2810	0.435	545	0.253	5.1
Baldwin sil	Sterling	1969	270	0.178	77	0.84	3152	0.344	612	0.193	6.7
Baldwin sil	Katy	1969	92	0.194	195	1.22	3443	0.332	1028	0.149	5.2
Baldwin sil	O'Neil	1969	48	0.200	171	1.15	3638	0.438	1031	0.209	5.9
Baldwin sil	Bellevue	1969	91	0.174	121	1.04	3583	0.285	950	0.140	5.9
Baldwin sil	Bellevue	1970	42	0.175	146	0.84	2699	0.300	998	0.191	5.7

MATERIALS AND METHODS

Topsoil and leaf-blade samples were obtained from 28 field experiments with first stubble sugarcane. The soil samples were taken in the spring prior to fertilization. A leaf-blade sample, composed of 20 leaf blades, was obtained from the 160-0-0 treatment in each experiment. The experiments were established primarily to study applied variables other than individual plant nutrients and had a common treatment, the 160-0-0. Leaf blades were obtained from the first leaf below the top visible dewlap when the sugarcane was approximately 3 months old.

Plant nutrients extractable from soils and soil pH were determined by standard methods used by the Louisiana Agricultural Experiment Station Soil Testing Laboratory (1).

Leaf samples, weighing 1 gram, were digested with concentrated nitric and perchloric acids. Salts from the sample were dissolved in 10 ml of 5N HCl and diluted to 100 ml volume. The total P in leaf samples was determined by the chlorostannous-reduced molybdophosphoric blue method in hydrochloric acid system (9). The Beckman Model DU spectrophotometer, with flame attachment and photo-multiplier assembly, was used to determine K and Ca contents of all samples and was used to determine Mg contents of samples collected during 1965, 1966, and 1967. The Perkin-Elmer atomic absorption spectrophotometer, Model 303, was used to determine Mg contents of leaf samples collected since 1967.

Prior to analysis of the digested samples for Ca and Mg contents, NH_4OH separation was made to remove Fe, Al and P, which may interfere with determination of Ca and Mg, particularly by the flame emission method (9). Simple standard curves were found to be adequate in the determination of Ca contents of samples. In the analysis of samples for Mg by the flame emission method, standards containing several Ca/Mg ratios were used to develop sets of curves for minimizing the potential error associated with Mg determination in the presence of Ca. After Ca values were ascertained, tentative Ca/Mg ratios in plant samples were calculated and tentative Mg values were obtained. By work with the curves and successive approximation of Ca/Mg ratios in samples, the final Mg values were obtained. The effect of Ca on Mg determination by use of the atomic absorption spectrometer was found to be negligible.

RESULTS AND DISCUSSION

Results from soil and leaf-blade chemical analyses are shown in Table 2 and in Figures 1 and 2. Table 3 contains selected correlation coefficients (r) showing relationships among the variables studied.

The relationship between P extractable from the soil(X) and the P content of leaf blades(Y) was highly significant ($r=0.524$). The relationship is shown graphically in Figure 1. Although the r-value was highly significant, it accounted for only 27.5%(R^2) of the variability in the relationship. The R^2 values obtained from previous work between P extractable from the soil and yield response due to application of normal superphosphate (containing both P and S) have ranged from 18.2 to 48.4% (6). Work now in progress with P and S as independent variables should result in more realistic correlations between extractable P and yield response to fertilizer P when a sufficient number of experiments has been completed.

Although the relationship between leaf P and leaf K ($r=0.366$) was almost significant (Table 3), it only accounted for 13.4% of the variability and generally did not tend to corroborate results from other similar studies with sugarcane (12).

The relationship between K extractable from the soil(X) and the K content of leaf blades (Y) was highly significant ($r=0.695$). The relationship is shown graphically in Figure 2. Leaf-P and leaf-K data, which are summarized in Table 4 from information in Table 2, show that the K status of sugarcane was generally lower than the P status in the experiments which probably accounts, in part, for the better correlation between extractable K and leaf K.

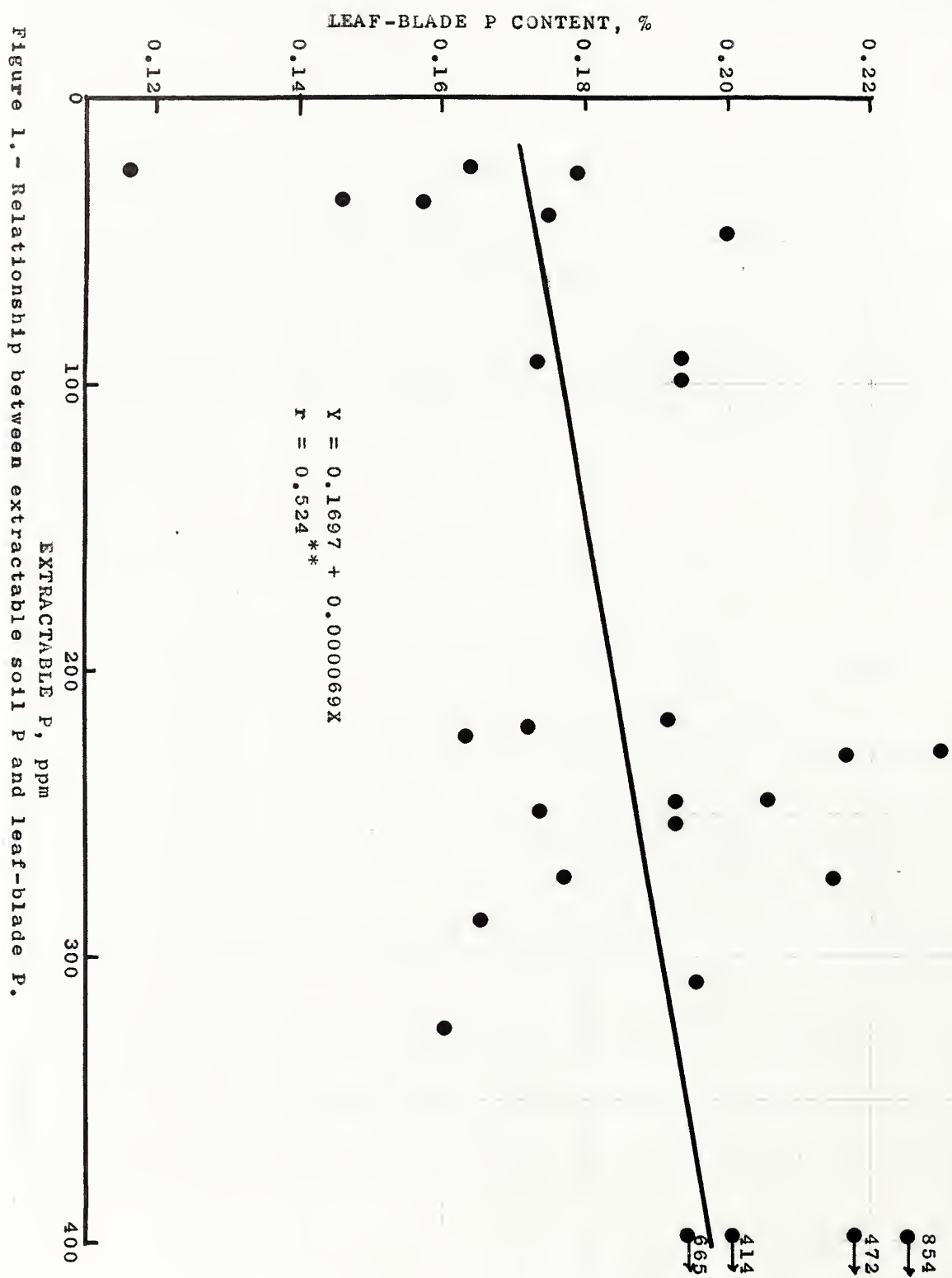
TABLE 3. Selected 1/ simple correlation coefficients(R) among chemical data from soils and leaf blades of sugarcane.

	Leaf P	Ext. P	Leaf K	Ext. Ca	Leaf Ca	Ext. Mg	Leaf Mg	pH
Ext. P	0.524		0.353					0.294
Leaf P			0.366					0.303
Ext. K			0.695	0.658	-0.342	0.691	-0.582	
Leaf K				0.463		0.413	-0.591	
Ext. Ca					-0.406	0.829	-0.491	
Leaf Ca						-0.501	0.471	0.278
Ext. Mg							-0.559	

1/ Correlation coefficients smaller than 0.250 were not tabulated.

Least significant r at the 1% level = 0.478

Least significant r at the 5% level = 0.374



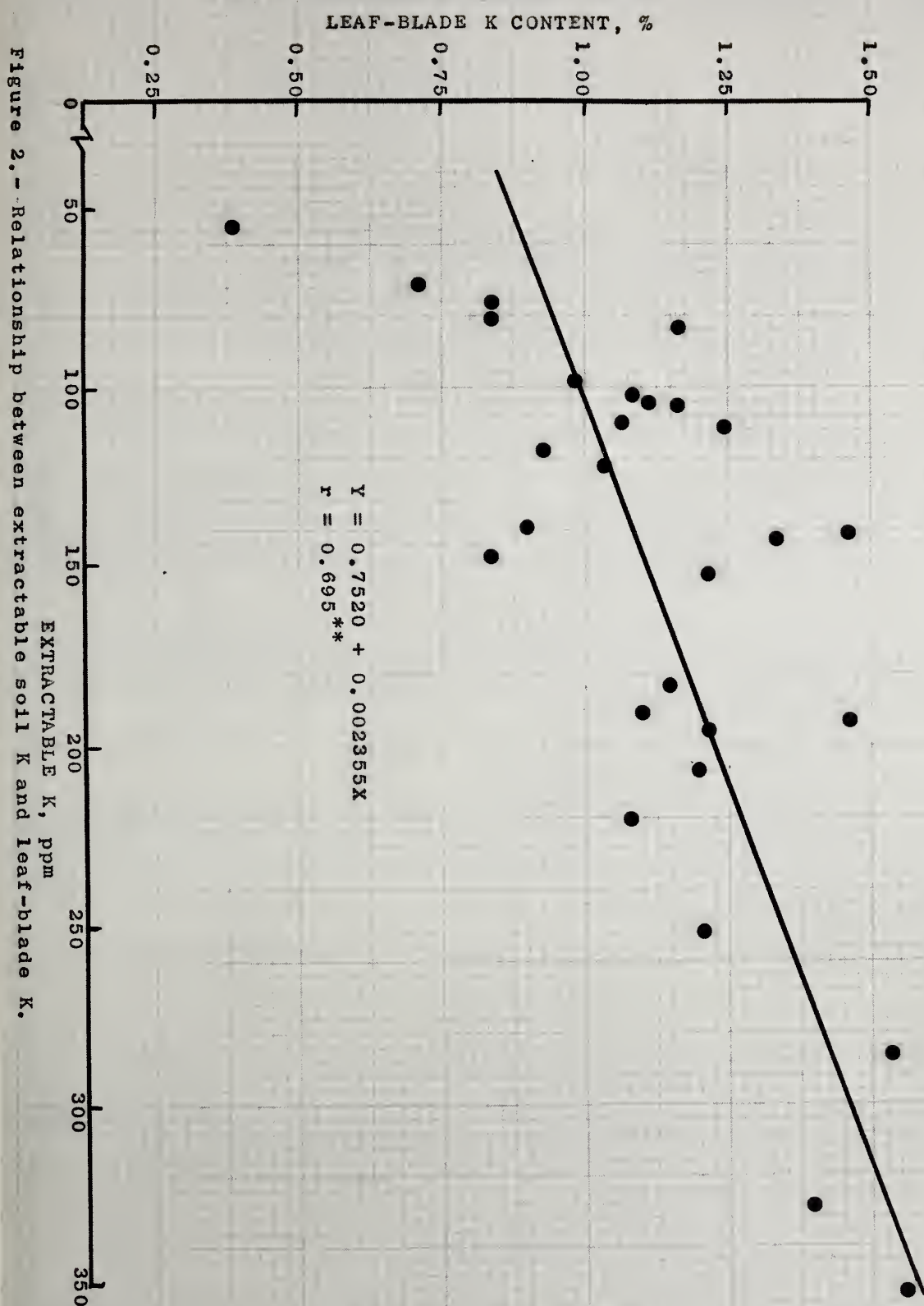


TABLE 4. Number of locations of experiments in each nutritional status.

Soils	Nutritional status 1/					
	P			K		
	Low or very low	Medium	High or very high	Low or very low	Medium	High or very high
Mississippi alluvial	5	10	2	11	6	0
Pleistocene terrace	8	3	0	10	1	0

1/ According to criteria shown in Table 1

The relationship found in previous work by Ricaud (10) between K extractable from the soil and response of sugarcane to fertilizer K was highly significant ($R=0.698$).

The better correlations found in this study and in previous work between extractable K and leaf K and between extractable K and yield response to fertilizer K suggest that predictions of yield increases due to applications of fertilizer K are more reliable at present than predictions of yield increases due to fertilizer P which are based on P data from this study and previous work.

The highly significant correlations between extractable K and extractable Ca ($r=0.658$), between extractable K and extractable Mg ($r=0.691$), and between extractable Ca and extractable Mg ($r=0.829$) are similar to correlations found in the sugarcane producing area of Louisiana by others (10, 11).

It may be noted in Table 3 that leaf K and leaf Mg were negatively related ($r=-0.591$). Since extractable K and extractable Mg were positively related, it appears that some cation antagonism between K and Mg occurred at the soil-root interface or within the sugarcane plant which resulted in the negative relationship found in leaf blades. There was apparently little cation antagonism between the di-valent ions, Ca and Mg, since extractable Ca and extractable Mg were positively related ($r=0.829$) and leaf Ca and leaf Mg were also positively related ($r=0.471$).

The lowest leaf-Ca value reported in Table 2, 0.253%, was considerably higher than the critical level, 0.13 to 0.15% (5), and the range in leaf-Ca values, 0.253 to 0.482%, was within the normal range of leaf-Ca values (4). The lowest leaf-Mg value reported in Table 2, 0.128%, was higher than the critical level, 0.06 to 0.08% (5), and the range of leaf-Mg values, 0.128 to 0.331%, was within the normal range of leaf-Mg values (4).

The range in extractable soil Ca (Table 2), 1791 to 5942 ppm, was much higher than the critical level, approximately 100 ppm, reported in Hawaii (8).

It was concluded from the information presented concerning Ca and Mg that additions of Ca and Mg as plant nutrients generally are not needed in Louisiana. Although the negative relationships between extractable Ca and leaf Ca ($r=-0.406$) and between extractable Mg and leaf Mg ($r=-0.559$) were significant and highly significant, respectively, they are considered to be of little practical significance in the soil testing program for the sugarcane producing area of Louisiana since lime recommendations are based only on soil pH.

Correlations between soil pH and the other variables in the study were not significant.

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EXPERIMENTAL MECHANICAL HARVESTING & CLEANING SUGARCANE
AT THE UNITED STATES SUGAR CORPORATION

Joseph P. Sexton

ABSTRACT

This paper relates the experiences of the experimental harvesting and cleaning operations of The United States Sugar Corporation. It gives a brief description of the equipment and operations, and some of the problems that are encountered in such an operation.

INTRODUCTION

During the past 3 seasons, the U.S.S.C. has been operating a semi-commercial harvesting program. This past season, we put all of the mechanically harvested cane through our experimental cleaning station.

The first year we ran one operating harvester, the 2nd year, 3 harvesters, and the 3rd, 2 harvesters. The reduction of the number of harvesters used for the third year was primarily due to the problems we had with our cleaning station. The harvester we used was developed by United States Sugar Corporation and were patterned after our continuous cane loader. It might be called a top, cut, chop, blow, and load sugar cane combine.

For those who are not familiar with the U.S.S.C. harvester, I will give a brief description of the machine. This machine is designed to operate in both upright and recumbent cane, as our Company has to harvest both kinds in varying amounts during the season.

The topper, which is mounted to the side of the machine, tops the row to the right of the row being harvested, and carries the cane tops behind and to the far side of the machine to keep it from being picked up by the harvester on its next trip around the field. In order to do the best possible job on topping, the topping height is controlled by an operator, whose only job is to top the cane at the proper height. Obviously, it is much more effective in upright cane than it is in recumbent cane.

The auger on the front of the harvester will lay down any cane that is standing upright, and put it in a position similar to that of recumbent cane.

The saw on the right cuts off any entangled cane laying near the ground. The ground knife severs the cane at ground elevation, and the chains pick it up and carry it to the cutting device. This cutting device then cuts the cane stalks into short pieces, between 10 and 20" long, regardless of the direction the cane is laying when it enters the device. The chopped cane then falls into a conveyor that delivers the cane into a string of wagons moving along the side of the harvester.

One of our harvesters has a propeller fan arrangement that blows air through the cane as it comes out of the conveyor, and falls in the wagon. This over the wagon duct directs the removed trash down towards the ground. This type is being revised as we find we cannot keep the ducts on the machine. They are constantly being run into by tractors and wagons. This string of wagons then goes to the loading station where the cane is transferred to a rail car.

Our experience in mechanical harvesting has shown us several things that will benefit the machine operation.

One of the most necessary is a smooth, level field. This allows for closer ground cutting without getting stubble and dirt. The more recumbent the cane, the more important this close cutting, as a great portion of the cane is within one or two inches of the ground.

We have also found long, narrow fields are of great benefit, particularly if the machine operates around the outside of the field, as ours does. We have planted several fields that were especially prepared for harvesters. The fields are 1/2 mile long, and 400 ft. wide, with openings between each field. The fields allow ample headland for turning, and room to start harvesting and loading with no prior field preparation. We have also found a continuous operation is necessary to get maximum production. Stopping and starting and many short waits will reduce the out-put of a harvester considerably. Every effort is made to keep the harvester moving.

One of the major problems resulting from mechanical harvesting is the added trash including tops. This added trash increases the hauling requirements, not only for the additional trash, but also because we do not get as much weight per cubic foot in our transport system. The cane tops adversely affect the mill operation.

This past season we operated a cleaning station that was incorporated with our transfer station. This station was designed to handle 120 tons of cane per hour. It uses air and stripping rolls in its

operation. The air is blown through thinned falling cane, attempting to remove the light trash, and then unto stripping rolls, which are used to remove tops and attached trash from the stalks. We have a system of recirculating the air, and removing the trash from it, in an effort to reduce the amount of trash we put into the area around the station.

After several modifications and changes we finally got the station operating fairly well. We ran about 40,000 tons of cane through the station and removed an estimated 1500 tons of trash. We reduced the trash content from about 10.25% to 7.17%.

After the major mechanical difficulties were reduced our biggest problem was handling the trash. It would get into the duct system, and would require several shut downs during the day to clean it out. We also had to keep a crew around cleaning up and collecting the trash so it would not be a fire hazard. We started out by collecting it in manure spreaders and taking the trash back to the fields, and spreading it. Of course, the nearest field gets the most trash, and that field had to be plowed up and replanted. We finally ended up by taking the trash to a large vacant field and piling it up.

On a few occasions we put green cane through the cleaner, and we ended up filling one manure spreader full of trash from every wagon of green cane. We then used trucks to haul the trash off, by letting the trash fall on the ground, and loading the trucks and wagons with a grab loader.

One of the frustrating things about cane cleaning is after burning the field, topping the cane, blowing it on the harvester then sending it through the cleaning station, trash is still seen being blown out of the cane by wind on its last drop before mill processing.

During the off season this year, we are making several changes on the cleaning station in an effort to make it more effective. We are also remodeling one harvester, and building another harvester with increased field cleaning in mind. We feel considerable progress has been made in the mechanical harvesting and cleaning of cane, but much more work has to be done to produce a good, clean millable cane.

I have a motion picture showing our harvesting and cleaning operations which I will comment on as it is shown.

THE TOFT CH-364 ROBOT CANE HARVESTER AT FLORIDA SUGAR CORPORATION

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ABSTRACT

Florida operated a Toft CH-364 Robot Cane Harvester during the last 23 days of their 1970-71 crop. This harvester is produced by Toft Bros. Ltd, of Queensland, Australia.

During the 23 days of operation, the Toft Robot harvested 4,638.23 tons of cane. The cane was cut into one foot lengths by this harvester and trash was extracted by the machine to the extent that average trash for burned cane was only 5.63 percent compared with 3.79 percent for hand cut cane.

Experiments were conducted during the last 23 days of the 1970-71 crop at Florida Sugar Corporation with a Toft CH-364 Robot cane Harvester. This harvester is manufactured by Toft Bros. Pty, Ltd. Bundaberg, Queensland, Australia. The machine was delivered on January 30, 1971, by Glades Equipment Company of Belle Glade, Florida, agents for Toft Bros.

MATERIALS AND METHODS

The Toft CH-364 harvester is a single-row cane cutter, cleaner and loader. It is hydrostatically driven and is available as either a single engine tire-mounted model or a dual engine track-mounted model. The machine reported on here is the tire-mounted model.

The harvester cuts the cane cleanly at close to ground level with a circular base cutter with 12 replaceable triangular blades. The machine tops the cane, before being cut at the base, by a rotary cutter on an adjustable elevator arm. The cut off tops are batted to the side by a revolving square upper portion of the topping assembly. A pair of powered discs with short fingers revolving inward bring the stalks to the topping blade.

As the cane stalks enter the central portion of the machine they are cut into approximately one-foot lengths and dropped onto the slat conveyor which lifts the cut cane up and into the cross conveyor which loads into the truck or wagon. The cutter which chops the stalks can be adjusted to cut the cane in lengths anywhere from 8 inches to 18 inches.

Revolving pick-up scrolls lift reclining cane and pick up drums feed the cane into the harvester.

Cleaning is performed by three powerful suction fans. The first of these sucks trash out and drops it to the ground as the main cutter blade cuts the stalks into lengths. The second is a suction fan that pulls out trash and dirt as the cane is dropped from the first conveyor to the cross conveyor. The third fan is a suction fan that pulls out additional trash and dirt as the cane falls from the cross conveyor to the truck. The trash and dirt removed by the blowers is scattered over the field by the usual brisk Glades wind. This scattering of the trash makes it unnecessary to perform the trash spreading with machines following harvest, as is usual with the pile row method of hand cut cane.

RESULTS AND DISCUSSION

It quickly became apparent that the 10-ton, 4-wheel mounted machine required additional support to operate on the soft, peaty soils of the Eastern Division of Florida Sugar Corporation. This area is about 13 miles south-east of Lake Okeechobee. After an additional wheel was put on the loading side, the harvester proceeded with a very creditable job of cutting, cleaning and loading cane, during the 23 days remaining in the crop period.

The cutting in burned cane appeared superior to hand cutting and was especially noteworthy in not shattering the remaining stumps of cane. Cutting of unburned cane presented a number of difficulties and appeared impractical under present conditions.

The trash and dirt cleaning, although understandably not equal to hand cut cane, was remarkably good with burned cane. With unburned cane the degree of trash removal varies considerably, depending on the variety. A comparison of trash samples from the harvester loaded cane and from nearby hand cut cane is shown as follows.

Burned Cane:

<u>DATE</u>	<u>FIELD</u>	<u>VARIETY</u>	<u>HARVESTER CUT</u> <u>% TRASH</u>	<u>HAND CUT</u> <u>% TRASH</u>
Feb. 2, 71	L-10-30	CL 41-223	6.39	3.43
" " "	"	"	9.03	
Feb. 5, 71	L-9-30	"	5.84	
" " "	"	"	5.61	
" " "	L-13-19	"		2.63
" " "	L-16-19	"		5.84
Feb. 16, 71	L-15-31	CP 63-588	4.10	
" " "	"	"	2.82	
" " "	L-4-31	CP 57-603		2.90
" " "	L-16-31	CP 63-588		4.17
AVERAGE			5.63	3.79

Unburned Cane:

Feb. 19, 71	A-20-36	CP 57-603	10.28
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Production:

Time studies and production records were kept by Glades Equipment personnel and Florida Sugar Corporation personnel during the 23 days of operation. The harvester operated as well in light or heavy burned cane but, of course, the time required to load a truck averaged less in the heavier cane. Average gross time to load 9-10 tons of cane into a truck was about 13 minutes in cane that was 35 tons to the acre. This would be at the rate of 45 tons per hour. Loading rate per cut-hour varied from 39 to 84 tons cane per hour. Excepting the first two experimental days, the rate per day-hours varied from 16 to 53 tons cane per hour. The highest daily production was 429 tons of cane cut and loaded in 8 hours and 15 minutes gross time in the field, for an average production rate of 52 tons cane per day-hour.

A total of 4,638.73 tons of cane was harvested by the Toft Robot in the 23 days it operated. On six of these days the harvester was in the field less than 5 hours.

During this trial period there were many interruptions and delays not likely to occur in a regular production operation. From our studies and records we feel that an average production rate would equal or better 250 tons per day over the crop period.

Down Time And Repairs:

One of the most impressive results of our study of this harvester was the freedom from breakdowns. There were no major breakdowns during the entire 23 day period. The main cutting blade was changed twice and the base cutter blades were replaced three times. The rubber pads on pick up drums were replaced once. One broken hydraulic hose was replaced. Washing of the machine appeared a daily requirement as cane juice and muck would build up on some parts of the machine.

Experiment Comparing The Toft Harvester With The Regular Hand Cut System

This experiment was designed to determine whether the harvester wasted more cane than the regular hand-cut, continuous loader operation. Two fields of CL 41-223 plant cane were selected and divided into two parts each, after burning. One part of each field was harvested in the regular manner and the other part was harvested by the Toft Robot. Results of this experiment were as follows:

<u>FIELD L-9-30, 37.7 ACRES</u>	<u>HAND CUT</u>	<u>TOFT HARVESTER</u>
Days loading	1	2 1/2
Cane Rows	136	122
Acres	19.87	17.83
Total Tons	654.23	627.30
Tons Cane per acre	32.93	35.18
Trash	4.24%	5.73%
<u>FIELD L-10-30, 37.6 ACRES</u>		
Days loading	2	3
Cane Rows	124	134
Acres	18.07	19.53
Total Tons	620.65	680.05
Tons Cane per acre	34.35	34.82
Trash	3.42%	7.71%

From the above can be seen that trash is slightly more with the Toft Harvester but recovery of cane from the fields is at least as good with the harvester as with the standard method.

Comparative Juice Samples - Hand Cut vs Toft Harvester

These experiments were set up to compare juice quality, which would also reflect cleaning and top removal.

In one experiment a field of CL. 41-223 plant cane was divided into two parts; one part harvested by hand cut method, the other part with the Toft Harvester.

Another experiment was with two fields of C.P. 63-588 plant cane that were separated by a fire lane only.

The third experiment compared two fields of C.P. 57-603 plant cane separated by a fire lane.

These are averages of four crusher juice samples.

FIELD	VARIETY	HAND CUT			TOFT HARVESTER		
		BRIX	SUC.	PUR.	BRIX	SUC.	PUR.
A-13-36	C.P. 57-603				17.50	14.55	83.16
A-14-36	"	17.81	14.62	82.11			
L-9-30	CL. 41-223	18.63	16.09	86.08	18.96	16.04	84.46
L-15-31	C.P. 63-588				18.68	16.26	87.05
L-16-31	"	17.74	15.50	86.03			

The above was taken late in the season with good burns. The results are very favorable. The better purities shown with the Toft harvester may be due to a time element because some of the cane would be to the crusher in one half hour after burning and the hand cut cane up to 48 hours.

Harvesting of Unburned Cane

Attempts to harvest unburned cane with the Toft machine presented a number of difficulties. We had set aside a small area of two new varieties for the test. These varieties (C.P. 66-2197 and C.P. 66-2207) were selected because of their shedding characteristic and somewhat erect growth.

The machine started cutting these fairly well but, in a short time, dry trash on the exhaust pipe caught fire and the unburned cane quickly became burned cane.

The second test of unburned cane was in field of 36 T.C.A. plant C.P. 57-603. Only one outside row was cut. There was no fire but the operator had difficulty seeing the row and the machine choked two times at the front end. Loading was very slow and a trash sample showed 10.28% trash.

CONCLUSION

In a round pattern of loading, considerable time is consumed going around the ends of the field. This varies, largely due to the number of rows remaining to be harvested. The time varied from 1 1/2 to 6 minutes per truck load of 9-10 tons. Loading efficiency would be considerably improved with rows long enough so that a truck would never have to make more than one turn. In planting fields, with mechanical harvesting in view, firelanes could be omitted and two fields joined into one or the firelane could run lengthwise rather than across the rows. In this latter method, the fields could be about the same area as at present but narrow and long rather than more or less square.

The machine we used has a screened cab for the operator. This was not enough protection for the operator from the cloud of muck dust and trash. A respirator and goggles were worn by the driver but it seems as if an air conditioned cab would more than pay for itself in increased efficiency.

We can say, in general, that our experience with the Toft Harvester has been encouraging and a step toward more economical cane harvesting.

Some changes can be made to improve this harvester. Some of these are: air-conditioned operators cab, larger fuel tank with measuring device, mirrors or some see-through device to improve operators view of the topping and a structural change or flap on the machine to prevent the occasional spilling of cane as it is dropped into the loading conveyor.

At present, plans are being formalized to continue, and probably expand, the trials with mechanical harvesters.

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Mr. Brines Strong and Mr. Earl Stuart and their staff from Glades Equipment Company provided some of the data in the foregoing paper. They also trained Florida Sugar Corporation operators and at the outset supervised and operated the harvester.

SUGARCANE SEEDPIECES: HEAT TREATMENT AND INOCULATION
WITH SUGARCANE MOSAIC VIRUS

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ABSTRACT

Seedpieces of the sugarcane variety Co. 312 were heat-treated and subsequently inoculated with one of 4 strains of the sugarcane mosaic virus before germination. The plants developing from these buds were observed for symptoms. Experimental results indicated a variety of responses ranging from an increased to a decreased incidence of infection, and from an increased rate of symptom appearance to a rate comparable to that of the non-treated. The increases in susceptibility following heat treatment in a local lesion host (the yarwood effect) and in sugarcane, inoculated either at the seedpiece or at the young plant stage, appear to be similar phenomena.

INTRODUCTION

Heat-treatment of sugarcane seedpieces increases the susceptibility to infection of the young plants developing from them when the leaves of these young plants are inoculated with sugarcane mosaic virus (Bourne, 1962; Zummo, 1967). The effect on susceptibility is twofold: More of the plants are infected, and the treated plants express symptoms more quickly. Young plants were inoculated 23-24 days (Bourne, 1962) or 9-13 days (Zummo, 1967) after the heat-treatment of the seedpieces. Bourne's results indicated that plants from treated seedpieces behaved similarly, whether the treatment had been given with hot air (54°C--8 hr) or with hot water (50°C--2 1/2 hr). Zummo (1967), who reported only on hot-air treatments, found that the presence or absence of the ratoon stunting disease did not affect the heat-induced susceptibility to mosaic.

A heat-induced susceptibility has also been reported for physiologically supra-optimal temperatures when heat-treated dicot leaves are infected with certain viruses that cause local lesions (Yarwood, 1956; Resconich, 1961; Liu and Silberschmidt, 1961). The treatment of one leaf on a plant may affect the susceptibility of leaves (Yarwood, 1961) or the movement of virus (Resconich, 1963) in parts not directly treated.

There are several differences in the heat-induced susceptibility between sugarcane plants and the dicot leaves that are local-lesion hosts. On sugarcane, symptoms appear on leaves to which the virus has spread rather than on the inoculated leaves as in local-lesion hosts. The sugarcane leaves to be inoculated and those to become diseased are in embryonic form when heat-treated, but the dicot leaves are relatively mature. The interval between heat-treatment and inoculation in sugarcane is so long that during such an interval any effect on susceptibility of dicot leaves would have disappeared. The heat dosage used for the treatment of seedpieces is many times that which dicot leaves could survive. These differences suggest that the effect of heat-treatment on susceptibility in sugarcane is an indirect one. Zummo (1962) proposed that the increased susceptibility in the field was due to the more rapid growth from heat-treated seedpieces, but both Zummo (1967) and Bourne (1962) discount earlier growth of the treated cane as a factor in the greenhouse.

If seedpieces of sugarcane were directly inoculated while the bud is still dormant, the variation associated with the inoculation of growing plants could be avoided, and the interpretation of heat-induced susceptibility could be simplified. Such direct inoculations with sugarcane mosaic virus (SCMV) have been reported (Wilbrink, 1929); seedpieces could become infected by cutting with a contaminated knife, but the results varied from time to time and a varietal effect was suggested. The application of seedpiece inoculation to studies of heat-induced susceptibility requires the development of a technique and the selection of a variety more generally responsive to this type of inoculation than has been available previously.

The heat-induced susceptibility to mosaic infection of sugarcane inoculated while the bud of the seedpiece is ungerminated forms the subject of this paper.

MATERIALS AND METHODS

Several varieties of sugarcane were selected, including the noble varieties, Saccharum officinarum, cv Louisiana Striped and Otaheite, and the interspecific hybrids Co. 285, Co. 312 and Co. 740.

Stalks of cane with mature nodes were harvested from stools grown in the greenhouse or in the field. Stools infected with mosaic were rejected, but those infected with the ratoon stunting disease were used

in certain experiments. Each node of a stalk was numbered before a stalk was divided into one- or two-bud seedpieces. The seedpieces were randomized and assigned so that buds from every stalk were represented in every treatment, though not always with equal frequency.

The seedpieces were heat treated either with hot water or with hot air. The hot-water bath maintained the 50°C temperature within a fraction of a degree; temperature distribution was uniform. For hot-air treatments, an electrically heated oven with a built-in fan was used. The oven maintained a temperature of 52± 3 C. During heat treatment, the seedpieces were wrapped in a paper bag to reduce drying.

The inoculum was prepared from young leaf blades of sugarcane infected with known strains of SCMV by blending leaf tissue and 0.01N sodium sulfite in a proportion of 1:4 to 1:10. The mixture was strained through cheesecloth, and silicon carbide abrasive (80 and 3F mesh) was added. The inoculum was applied to the interior of the stalk tissue with an airbrush (125-150 p.s.i.).

Before inoculation, all seedpieces to be inoculated, or to serve as non-inoculated controls, were cut into one-bud seedpieces which were approximately 6-7 cm in length and symmetrical around the leaf scar. Immediately before inoculation the seedpieces were split lengthwise with a meat cleaver; the split was directed through the center of the cylinder so that the bud had equal rind on both sides. The budded half was inoculated, the other half was discarded. The seedpieces not inoculated were split in the same way in most of the experiments; the person who split the cane did not do the inoculation.

After the seedpieces had been split (and inoculated, or not, as appropriate), they were placed, bud down, on moist towelling in covered glass dishes. The seedpieces were kept in an incubator at about 26°C for 1 to 3 days. They were then planted in sterilized vermiculite in peat pots placed on sterilized soil in metal flats. The plants growing from the seedpieces were observed over a period of at least 3 months.

To minimize the chance of accidental contamination by aphids, the plants were grown in a screened greenhouse fumigated weekly. The plants were usually checked daily for symptoms of mosaic, and those with symptoms were removed. With these precautions, accidental contamination by aphids, as judged by a single diseased plant from an uninoculated seedpiece, was reduced to an overall incidence of less than 1%. On two occasions, a stalk infected with mosaic was accidentally included in the experimental material; all plants from inoculated and uninoculated seedpieces derived from this stalk developed symptoms; these seedpieces were discounted.

In most of the experiments, the records for each infected plant included the date when symptoms were first observed; the number of leaves with dewlap exposed on that date; and the position of the oldest leaf to show symptoms. These data were used to determine the interval, inoculation to first appearance of symptoms, and the "leaf symptom number" (the number of the oldest leaf with leaf blade to show symptoms counting from the bottom upward).

RESULTS

Among the varieties examined, Co. 312 had the greatest susceptibility to infection by seedpiece inoculation. The other varieties either showed less susceptibility (Co. 740 and Co. 285), or varied widely in incidence of infection from time to time (Louisiana Striped and Otaheite). In conventional greenhouse tests, the variety Co. 312 had shown no recovery from infection with any of the strains of SCMV.

From the 16 experiments in which Co. 312 was used, eight were selected for inclusion in Table 1. There was much variation among these experiments, both intentional and unintentional. As shown in Table 1, the interval between harvest and heat treatment varied, as did the interval between heat treatment and inoculation, and the strain of the virus used in the inoculum. Furthermore, the infectivity of the inoculum varied among experiments; the seedpieces, except those for Experiment 5, were derived from field-grown cane immature in August and maturing during November and December; and, especially during winter months, the light and day temperature varied in the greenhouse where the plants from the treated seedpieces were developing.

The results of the experiments of Table 2 may be divided into four categories. (1) Heat treatment increases the incidence of infection compared to the non-treated (Experiments 1, 2, and 3). (2) A shorter heat treatment increases, and a longer heat treatment decreases, the incidence of infection among the treated compared to the non-treated (Experiment 4). (3) Heat treatment apparently does not increase and may decrease the incidence of infection among the treated compared to the non-treated (Experiment 5). (4) As a special case of the third category, the incidence of infection among the non-treated is over 90% (Experiments 6, 7, and 8).

For the 15 experiments which involve hot-water treatment, the results of six fall into the first category, of two into the second, of four into the third, and of three into the fourth. In the third category, a heat treatment of one duration only was used in three of four experiments. The results of the hot-air treated cane of the 16th experiment fell into the first category. Heat treatment thus increased the incidence of infection in 9 of 16 experiments.

Heat treatment appears to be most important among the factors that affect survival (Table 2). Inoculating split seedpieces does not seem to affect adversely the percentage of survivors (Table 2).

For the higher heat dosages, fewer survivors among the treated may be associated with fewer diseased among survivors (Experiments 3, 4, and 6), but the percentage diseased may also decrease without a commensurate decrease in survivors (Experiments 5 and 8).

The plants derived from heat-treated seedpieces show symptoms more quickly (Table 3) and earlier in their development (Table 4) than do those from non-treated seedpieces. Although the data for Experiment 3 are sparse, the results indicate that the plants from seedpieces more briefly heat-treated (30-min) respond more quickly to the virus than do those from seedpieces treated longer (120-min) or not treated. The results of Experiments 6 and 7 indicate that although heat treatment did not increase the incidence of infection, it decreased the time to first appearance of symptoms. The plants of Experiment 9, derived from seedpieces treated with hot air, responded as did those from seedpieces treated with hot water.

The interval between inoculation and the appearance of symptoms, by itself or in combination with the leaf symptom number, is not a direct indication of growth because germination and early growth are not uniform. Thus, in Experiment 1, plants on which symptoms first appeared on the fourth oldest leaf with leaf blade showed their first symptoms from the 5th to the 10th week after inoculation. In general, the appearance of symptoms at an earlier time and at an earlier stage of development tends to be parallel (Tables 3 and 4), but there are exceptions as in Experiment 3 for the 120-min treatment. The variability in the rate of development makes it difficult to identify trends where only a few plants are involved.

In several experiments, seedpieces treated with hot air were inoculated; in some varieties (Otaheite, Co. 312), the resulting plants showed an increased incidence of infection, while in other varieties (Louisiana Striped, Co. 740), they did not. In the only hot-air experiment with Co. 312 (Experiment 9) stalks were harvested in the field in December, 1968: The seedpieces were prepared on that day, then were treated for 20 hrs. ($52 \pm 3^\circ\text{C}$), and next day were inoculated with strain D. From the 9 treated and inoculated seedpieces, all 8 plants that grew developed symptoms. From the 9 non-treated and inoculated seedpieces, 3 of the 8 plants that grew developed symptoms. None of the plants from non-inoculated seedpieces developed symptoms, neither the 9 from treated nor the 9 from non-treated seedpieces. The increased incidence of infection in Experiment 9 is accompanied by an earlier appearance of symptoms (Table 3 and 4).

No single treatment or combination of treatments increased the susceptibility to infection regardless of variety. Susceptibility may be modified by heat, but it itself is obviously dependent on other factors. The seedpieces of Experiment 3 (Table 1), for example, were heat-treated together and inoculated together, and the plants from these seedpieces were grown together, with those of variety Co. 285, but no plants from this variety became infected.

DISCUSSION

The interaction of heat treatment and infection in seedpieces (Table 2) may be interpreted as an effect of heat dosage (temperature x duration) on susceptibility; the dosage may augment or inhibit the incidence of infection. The dosage-response interaction is assumed to follow an optimum curve. The susceptibility increases as the length of the heat-treatment increases to an optimum; beyond the optimum, an increase in the length of the treatment would lead to a progressive decline of susceptibility. In this interpretation, dosages ranging from suboptimal to supraoptimal would increase susceptibility; too low a dosage or a dosage in the supraoptimal range at the threshold of inhibition would leave susceptibility apparently unchanged. Supraoptimal dosages in the inhibitory range would decrease susceptibility. A dosage-response curve of this type was plotted by Liu and Silberschmidt (1961) for the incidence of local lesions on tobacco with Tropaeolum mosaic virus.

The results of Experiment 1 confirm for heat-treated and inoculated seedpieces the reports of Bourne (1962) and Zummo (1967) for inoculated sugarcane plants derived from heated seedpieces: a higher incidence of infection (Table 2) and a more rapid appearance of symptoms (Tables 3 and 4). Although often found together, these two aspects of heat-induced susceptibility appear to be separable phenomena. In Experiments 6 and 7 (Table 2), even though the incidence of infection among the non-heat-treated is as high as or higher than that among the heat-treated, heat treatment still increases the rate of appearance of symptoms (Tables 3 and 4). This finding parallels the observation of Resconich (1959) that under certain conditions the local lesions appear earlier on heat-treated bean leaves even though the incidence of symptoms is not increased.

The data of Experiment 3 suggest that when the survival and incidence of infection are lowered by a 120-min heat treatment, as compared to a 30-min heat treatment (Table 2), the rate of appearance of symptoms (Tables 3 and 4) may also be decreased. Resconich (1961) observed that at supraoptimal dosages both aspects of heat-induced susceptibility on bean leaves are abolished.

Bourne's results (1962) with inoculated plants from heat-treated seedpieces showed that both hot-air and hot-water treatments have similar effects on heat-induced susceptibility. Similar effects as a result of the two types of heating have also been noted with heated and inoculated sugarcane seedpieces (Experiment 9, Tables 3 and 4) and with heated and inoculated bean leaves (Resconich, 1959).

The response to heat and inoculation in sugarcane appears to be no different whether the heated seedpieces themselves or the plants derived from them are inoculated. When the extensive data of Zummo (1967) on inoculated young plants derived from hot-air-treated seedpieces are compared with hot-water-treated and inoculated seedpieces, the range of responses is the same. Zummo's data can be divided into categories, just as Experiments 2, 5 and 6 of Table 2 have been divided. The close similarity among the results is the more remarkable inasmuch as different varieties of sugarcane are involved. If heat-induced

susceptibility in seedpieces and in the plants derived from them is the same phenomenon, the effect of heat probably depends on the same mechanism in both cases. It does not seem likely that the effect of heat depends on the dissimilar tissues inoculated (leaf and stalk); it is more likely that heat involves the phases of infection that are similar: movement of virus within the plant and expression of symptoms on the young leaves.

The heat-induced susceptibility of inoculated sugarcane seedpieces is comparable to that of dicot leaves and to that of inoculated sugarcane plants derived from heat-treated seedpieces. This similarity suggests that one or more heat-responsive systems regulate the susceptibility to infection in each case. The long-lived effect of heat treatment, which extends, in sugarcane plants, to tissues unformed at the time of inoculation, brings out in more acute form the question of how the "memory" of heat treatment is stored in each one of the three systems.

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TABLE 1. Conditions for experiments involving hot-water treatment (HWT) and inoculation with sugarcane mosaic virus (SCMV) of seedpieces of sugarcane variety Co. 312.

Experiment	Begun	Interval (days)		
		Stalks cut	HWT to	SCMV
No.	(Mos., Year)	to HWT	Inoculation	Strain
1	Dec. 68	4	1	A
2	Dec. 68	8	1	H
3	Nov. 69	0	0	D
4 ^{1/}	Nov. 70	4	0	D
5 ^{2/}	Aug. 69	0	0	B
6	Dec. 68	1	- 1	D
7	Dec. 68	5	0	D
8 ^{1/}	Aug. 70	4	0	D

^{1/} All cane infected with ratoon stunting disease.

^{2/} Greenhouse-grown cane; all others field-grown.

TABLE 2. Infection with sugarcane mosaic virus (SCMV) following hot-water treatment (HWT) and inoculation of seedpieces.

Expt.	HWT 50°C	Inoculated				Non-inoculated			
				Survivors Diseased				Survivors Diseased	
		No.	No.	among treated	among survivors	No.	No.	among treated	among survivors
No. ^{1/}	(min)	treated	diseased	(%)	(%)	treated	diseased	(%)	(%)
1	120	32	29	94	97	32	1	94	3
	0	33	17	91	57	33	0	91	0
2	120	20	12	90	67	19	0	95	0
	0	20	2	95	11	20	0	100	0
3	120	12	5	50	83	12	0	75	0
	30	12	12	100	100	12	0	83	0
	0	12	3	100	25	12	0	92	0
4 ^{2/}	60	19	0	53	0	-	-	-	-
	20	19	15	84	94	-	-	-	-
	0	19	3	89	18	19	0	68	0
5 ^{3/}	120	28	4	82	17	26	0	96	0
	32	25	6	84	29	23	0	96	0
	0	23	6	91	29	24	0	88	0
6	123	15	5	47	71	4	1	100	25
	0	15	13	93	93	7	0	71	0
7	122	12	9	92	82	11	0	82	0
	0	12	11	100	92	12	0	100	0
8 ^{2,3/}	60	17	3	94	19	-	-	-	-
	20	17	8	100	47	-	-	-	-
	0	17	14	88	93	17	0	88	0

^{1/} Experiments as in Table 1.

^{2/} Controls not split lengthwise.

^{3/} One cane infected and its seedpieces discounted.

TABLE 3. Infected plants classified according to the weeks elapsed between inoculation and the first appearance of symptoms.

Expt.	Treatment ^{2/}	Weeks between inoculation and first symptoms							
		3	4	5	6	7	8	9	≥ 10
1	HWT	0	8	14	2	4	0	0	1
	NT	0	0	2	1	7	3	0	4
3	HWT (120-min)	0	0	0	0	1	1	0	3
	HWT (30-min)	8	3	1	0	0	0	0	0
	NT	0	0	2	0	0	0	0	1
6	HWT	1	2	1	0	1	0	0	0
	NT	0	0	4	3	3	1	0	2
7	HWT	0	1	6	2	0	0	0	0
	NT	0	0	0	1	4	1	4	1
9	HAT	4	0	3	0	0	0	0	1
	NT	0	0	0	0	0	0	2	1
Total HT		13	14	25	4	6	1	0	5
NT		0	0	8	5	14	5	6	9

^{1/} See Table 1 and 2 for experimental details; for experiment 9, see text.

^{2/} HWT--hot-water treated; HAT--hot-air treated; HT--heat treated; NT--not heat treated.

TABLE 4. Infected plants classified according to "leaf symptom number", i.e., the oldest leaf with leaf blade, counting from bottom, to show symptoms of mosaic.

Expt.		Leaf symptom number						
No. <u>1/</u>	Treatment <u>2/</u>	2	3	4	5	6	7	≥8
1	HWT	0	12	12	3	1	0	1
	NT	0	1	3	5	7	1	0
3	HWT (120-min)	0	0	3	1	0	0	1
	HWT (30-min)	1	4	6	1	0	0	0
	NT	0	0	1	1	0	0	1
6	HWT	1	0	3	1	0	0	0
	NT	0	3	4	3	0	2	1
7	HWT	0	3	3	3	0	0	0
	NT	0	0	2	6	1	1	1
9	HAT	1	5	0	0	0	1	1
	NT	0	0	1	1	0	0	1
Total HT		3	24	27	9	1	1	3
NT		0	4	11	16	8	4	4

1/ See Table 1 and 2 for experimental details; for experiment 9, see text.

2/ HWT--hot-water treated; HAT--hot-air treated; HT--heat treated; NT--not heat treated.

WILTING AND DEATH IN THE RATOON STUNTING DISEASE OF SUDANGRASS HYBRID UPRIGHTS

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ABSTRACT

Setts of a sorghum-Sudangrass hybrid (NB 280S) were inoculated with the virus of the ratoon stunting disease, and then were grown as uprights (unrooted aerial stools supported on the sett stalk and dependent on sett roots). After some weeks of growth, the shoots of these uprights wilted progressively and eventually died. Control uprights, grown in the same pot with infected uprights, survived without severe wilting. So did infected plants and control plants grown as usual on their own shoot roots. Several lines of evidence indicate that the virus is associated with the acute wilting of infected uprights: The wilting symptom follows only on inoculation with active virus; virus may be recovered from progeny; and the heat-treatment for the control of the ratoon stunting disease eliminates the symptom from the progeny uprights. The water loss from infected uprights was compared with the water loss from control uprights by the pot-weight method. Over a 21-day period, the proportion of water lost by infected uprights decreased from 90% of controls to 20%. The severe wilting of infected uprights from which the shoots did not recover followed a period of decreasing water loss.

INTRODUCTION

The ratoon stunting disease of sugarcane (RSD) may cause serious losses of yield in plants that show few if any symptoms (7). Without symptoms as a guide, and with great variability in normal growth, it has been difficult to identify the origin of the loss in yield. An extensive search of many varieties of sugarcane, sorghum, and corn has failed to uncover a host with well-defined external symptoms of RSD.

Growth studies on sugarcane (Saccharum interspecific hybrids and S. spontaneum var. Coimbatore) proved uprights to be useful in eliciting quantitative differences between RSD-infected and control plants (1). An upright is a stool grown from the one bud left intact on a sett of two or more nodes; the sett is placed vertically, so that the stool and its adventitious roots are completely above soil level; water and nutrients are supplied by sett roots (2). This method depends on the limiting aerial branching potential of monocots without secondary growth; these plants, regardless of branch size, can neither increase the amount of vascular tissue in the stem nor increase the area of attachment of the branch to the main shoot. In uprights, the physiological demands on the sett stem and on the region of attachment increase progressively with the growth of the aerial stool, but the anatomical capacity does not increase.

When setts of a Sudangrass hybrid were grown as uprights in the summer of 1969, all uprights that had been inoculated with the virus of the ratoon stunting disease wilted severely and eventually died. All the controls lived and continued to grow.

A series of experiments was begun in order to examine severe wilting and death in relation to infection with the RSD virus, and in relation to the pattern of water loss. This report summarizes these studies.

Materials and Methods

Seeds of the sorghum-Sudangrass hybrid NB 280S were planted in sterilized soil in metal flats. The seeds were placed approximately 3 by 5 cm apart in an 8 x 8 grid. The plants were allowed to develop until the flag leaves (the last leaf before the panicle) was exposed, or, more usually, until seeds were developing. The crowded conditions in the flat produced stalks of small diameter.

Preparation of setts involved harvesting stalks from the flat, stripping the leaves, cutting a segment of the stalk either of 3 or 4 nodes depending on the experiment, and removing all but one bud with a scalpel. The only bud remaining on the sett was either the youngest or the next older bud. Measurements on the seedpiece included the length between the furthest leaf scars, and the diameter of the middle of the internode below the bud.

Inoculation of the setts involved cutting through the terminal internode, top and bottom, and immediately dipping each end, as cut, in inoculum for about 10 seconds. The setts were left for 15 min or longer before placing in sufficient distilled water to cover the lowest node. The setts were then placed in the dark for a few days before transplanting to 10-, 15- or 25-cm clay pots. In most of the experiments, a soil mixture of 1 part coarse sand and 3 parts loam was used.

The setts were arranged on the greenhouse bench so that in each row and column infected and control uprights alternated. The pairs are arranged so that their buds face each other because the growth from uprights is lateral. While the pairs are initially selected at random, if one of a pair does not germinate, the pair is discarded or the relicts are rematched according to size.

The inoculum was prepared from stalks of RSD-infected plants, either sugarcane cv. CP 44-101 or infected Sudangrass hybrid. For sugarcane inoculum, the stalks were ground, then the juice extracted under pressure. For Sudangrass hybrid, the stalks, after cutting into small pieces, were ground in a food chopper; the broken stalk pieces were extracted by hand with or without the addition of distilled water. Aliquots of the inoculum were heated in boiling water for 20 min or more to inactivate the virus. Setts to be infected were inoculated with the unheated juice, control setts were inoculated with the juice which had been heated.

The treatment was assigned to the setts at random. One method used was to pile all the setts, flatten the pile until the setts were in one parallel layer, then number the setts consecutively; the odd-numbered setts were infected.

Measurements taken at intervals during the period of growth included the height of the main shoot from the attachment region to the youngest exposed junction of sheath and blade (dewlap); the number of leaves with leaf blade; and the number of axillary shoots in each size group (total length over 5 cm, 2 to 5 cm, less than 2 cm). In addition to these measurements, at the termination of the experiment, the total number of nodes with buds was determined (3); so were the internode length (measured from leaf scar to leaf scar), the fresh weight, the general appearance, and the flowering status. The statistical significance of differences was estimated with a ranking method (8).

Single-node cuttings were prepared from the main shoot and axillaries of uprights, as well as from stalks grown in flats or pots. Some of the cuttings from healthy plants were inoculated; others, from infected plants, were heat-treated by using hot water at 50°C for 2 hr. These cuttings were grown in peat pots filled with vermiculite and later transplanted to the sand-soil mixture in clay pots.

Assays for the presence of RSD-virus were carried out by using juice prepared from Sudangrass hybrid stalk tissue to inoculate seedpieces of sugarcane, cv. CP 44-101 (5). The young shoots from these seedpieces were examined for juvenile symptoms.

Water loss was determined in one experiment by using the pot-weight method. Seeds for this experiment were planted March 26, 1970; the plants were harvested June 2 at an early fruiting stage; four-node setts were prepared and inoculated. The uprights were grown from June 6 to July 14 in 10-cm clay pots; they were then transplanted into styrofoam containers, 16 cm in diameter x 16 cm deep, lined with polyethylene film. The containers were sealed with plastic tape except for an opening for the sett stalk and for watering, and another for a bamboo stake; these openings were plugged with cotton. For the period July 15 through August 4, the pots were weighed three times a day alternating control and infected, always in the same sequence. These weighings were made between 8:30 and 9:30 a.m. (morning), 12:30 and 1:30 p.m. (noon), and 4:30 and 5:30 p.m. (afternoon); each time, distilled water was added to replace that lost, and the amount added was determined by reweighing the pot. Three weighings were omitted, twice at noon, once in the afternoon. When transplanted, the plants had been well-watered. Water was added in excess of that used on the 16th (20 g), on the 18th (100 g), on the 22nd (30 g), and on the 31st (50 g). Weight of water lost daily, as well as daily incident sunlight, were measured over the 24-hr period from afternoon to afternoon.

The incident energy of sunlight was measured by means of a flat-response radiometer (Sol-A-Meter, DTI Corp., Tempe Arizona)* placed out-of-doors. The total energy received was noted just before each weighing time. The temperature and relative humidity were recorded on a hygrothermograph chart.

Resistance to gas diffusion through the leaf was measured with an Alvim-type porometer. Carbon dioxide uptake of leaves enclosed in a leaf chamber while still attached to the intact plant was determined by means of infra-red absorption (6).

Results

The Etiology of the Wilting

The wilting of the Sudangrass hybrid uprights were classified as mild if the fully grown younger leaves rolled at the distal end of the leaf blade, as moderate if the entire leaf blades rolled, and as severe if the leaf blades folded over along the midvein so that only the undersurface of the leaf was exposed. Mild and moderate wilting occurred in both control and infected uprights, but severe wilting was normally restricted to RSD-infected uprights.

The pattern of wilting associated with infected uprights is a progressive one. The first distinctive symptom is severe, midday wilting usually involving the main shoot and/or one or more of the

* Mention of a trademark or proprietary product does not constitute a guarantee of warranty of the product by the U.S. Department of Agriculture, and does not imply its approval to the exclusion of other products that may also be suitable.

axillaries. As the disease progresses, mild wilting occurs earlier in the day, severe wilting persists longer, and more shoots wilt; the affected shoots recover from wilting later and later until they no longer recover at night (chronic wilting), and the leaves eventually turn brown. As the main shoot and most of the axillaries reach chronic wilting, one or more axillaries may continue to grow, wilting severely only briefly during the middle of the day; eventually they too wilt chronically. Observations indicate that axillaries can recover from chronic wilting, but main shoots do not. Eventually, the entire aerial shoot of the infected upright dies.

The stage in the development of infected uprights at which severe wilting and chronic wilting begins is seasonally influenced. In one winter experiment which was terminated shortly after anthesis no severe wilting was noted; in summer experiments, the uprights often have died while the plant was still vegetative.

The wilting syndrome was restricted to infected uprights, even when infected and control uprights had been grown continuously in the same pot. In one of several such experiments, setts were prepared and inoculated June 2; they were planted, control and infected together, into 15-cm pots on June 6. In early development, the control and infected uprights had been indistinguishable. When the experiment was terminated in September, all of the 16 control uprights had formed seed; and 14 of the 16 were alive; 2 were broken off and had died. All 16 of the infected uprights were brown and deemed to be dead; 10 of these were vegetative, one had formed a flag leaf before dying, and 4 of the 5 that had flowered had dried out before seed set.

Severe wilting is associated with infected stools grown as uprights (infected uprights), but not with infected stools grown from single-node cuttings (infected plants). Such infected plants usually grew to maturity and were indistinguishable from control plants, whether the single-node cuttings from which they originated were inoculated directly or taken from infected plants or uprights. Only rarely, when grown under conditions of extreme moisture stress, have infected plants shown severe wilting. Uprights from infected plants show severe wilting, uprights from control plants do not. The onset of severe wilting in uprights taken from infected plants appears to occur earlier than in uprights infected as setts.

The normal growth of infected plants facilitates testing the effect of heat-treatment on the expression of the wilting syndrome. This heat treatment has been routinely used for the control of the ratoon stunting disease in sugarcane (7). Single-node cuttings were taken from wilting, infected uprights; some of the cuttings were heat-treated, others not, before they were planted. When the plants had grown for 3 1/2 months, setts were prepared and planted, and the uprights from these setts were grown for 3 1/2 months, until March, 1971. All 6 of the uprights from heat-treated plants were flowering and alive; 5 of the uprights from non-heat-treated plants were vegetative and all 6 were wilted or dead. There were large and statistically significant differences in height, leaf number, and fresh weight; the stronger growth of uprights from heat-treated plants was apparent from the first month.

In one experiment, the juice from stalks of infected plants was used to inoculate healthy setts. The amount of inoculum was not sufficient to prepare a boiled aliquot for control inoculation; and the control setts were either only cut, or cut and dipped in a boiled aliquot of sugarcane inoculum. The uprights infected with the inoculum from Sudangrass hybrid showed the characteristic wilting of the main shoot with one or more axillaries turgid; the control uprights were not wilted. The experiment was terminated early to prepare setts from these uprights, but setts taken from infected uprights failed to survive beyond the earliest stages of development.

The juices from stalks of infected plants derived from infected uprights, and of control plants derived from control uprights, were inoculated to sugarcane seedpieces for assay of virus. The results indicated that RSD-virus was present in infected plants, but not in control plants.

Wilting and Water Consumption:

The pot-weight experiment, as described in "Materials and Methods", measures loss of water. It is assumed that most of the water loss is due to transpiration. The base of the soil-root mass was in free water so that it is probable that the soil was maintained near field capacity throughout most of the day. The shoots of uprights, especially of the control uprights, showed signs of nitrogen deficiency at the termination of the experiment.

Sunlight, temperature, and relative humidity in the greenhouse environment tend to vary together. During the period July 14 to August 5, 1970, as the sunlight increased on bright days, the temperature rose from the early morning minimum of about 24°C to an afternoon maximum approaching 49°C. The relative humidity decreased from the night maximum near 100% to an afternoon minimum in the 30 - 40% range. On heavily clouded days, July 22 and 25, the temperature exceeded 38°C only briefly and the relative humidity remained more than 50%; on these days, water loss was notably less (Fig. 1). Total sunlight per day, even though measured outdoors, is a convenient index of the complex of environmental factors that affect water loss in the greenhouse.

The pattern of water loss appears to be consistent for the control uprights, on the one hand, and for the infected uprights, on the other. The water loss of control uprights resembles closely the curve for the incident energy of sunlight (Fig. 1); overall, the loss appears to increase with time, reflecting presumably the increased growth of the aerial stool. The water loss of the infected uprights decreased throughout this period, although the day-to-day variations also resemble the sunlight

curve. Initially, there was some overlap between the loss by control uprights on a cloudy day and the loss by infected uprights on a sunny day; at the end of the experiment, the gap in the amount of water lost precluded such an overlap. Over the period of the experiment, the proportion of the average daily loss of water of the infected uprights decreased from 90% of controls to 20%. This proportion varied significantly for the three periods of measurement each day, generally being highest in the morning, lowest in the afternoon. By the end of the experiment, the water loss had decreased in all 9 of the infected uprights over the first day, and had increased in all 9 of the controls.

The chronic wilting of the main shoot of infected uprights followed a period of decreasing water loss (Fig. 2). There was no indication on the day preceding or on the first day of wilting of an unusually high water loss; in each of the 5 uprights, the water loss was 75% or less of the water loss for that upright on the first day of the experiment (July 15).

When the pot-weight experiment was begun, the pairs of infected and control uprights did not differ significantly in size. The pairs selected had not differed significantly as setts either in length (ave. = 61 cm) or in diameter (ave. = 0.42 cm). On July 15th, the uprights were still vegetative. There was no significant difference between the control and the infected uprights in a) the height of the main shoot (ave. = 41 cm); b) the number of leaves with leaf blade and dewlap exposed (ave. = 9.8); and c) the number of axillary shoots (ave. = 2.4).

When the experiment was terminated, all of the control uprights had flowered and begun to set seed, and none were wilted. By contrast, 3 of the infected uprights were vegetative, and 5, including the 3 vegetative ones, had the main shoot chronically wilted. The bolting associated with flowering affects the height and leaf number, and wilting reduces the fresh weight. Because of the qualitative differences, the quantitative differences between control and infected uprights in height and in fresh weight (Table 1), both statistically highly significant, are flawed. The roots of all uprights appeared to be in excellent condition. The setts, both infected and control, bled profusely from the wounds made by detaching the aerial stool; one infected upright in which the sett was torn when the stool was detached did not bleed.

A further confirmation that the infected and control uprights had developed similarly was indicated by internode measurements. In both groups of uprights, the oldest internode longer than 1 cm was, on the average, near 7.3, when the internodes were counted from the oldest upward.

The chronic wilting of the main shoot may be accompanied by spurts of growth in one or another axillary shoot. In the most extreme case, an axillary shoot of an infected upright with a chronically wilted, vegetative main shoot grew until it exposed the flag leaf; at the time the experiment was terminated, this shoot also had been chronically wilted for some days, and another axillary, which had been wilted, had again become turgid.

The continued, fitful growth of axillaries at this stage of wilting affects the loss of water from the pot, and the loss of water per unit of fresh weight of aerial stool (Table 1). In the calculations of Table 1, the water loss is attributed to the stool (none to the sett), and it is assumed that the fresh weight of August 6 is about the same as on August 4. For the control uprights, the weight loss of water ranged from 1.97 to 2.24 times the fresh weight, for an average loss of 2.16 times; for the 5 infected uprights with chronically wilted main shoots, the weight loss of water ranged from 0.26 to 0.42 times the fresh weight, with an average loss of 0.37 times; for the 4 infected plants not chronically wilted, the weight loss of water ranged from 0.77 to 1.00 times the fresh weight, with a mean of 0.91 times. These figures show that the decreasing loss of water from infected uprights is not the result only of a lighter weight in plant.

The Alvim porometer measures the time required for a pre-determined drop in air pressure from diffusion of air between the lower and the upper surface of the leaf. The slower the pressure drops, the less permeable is the leaf; and in sugarcane, the time required is correlated with the number of stomates closed (6). The results with infected uprights that were wilted indicated that the youngest fully-expanded leaf was practically impermeable, whether the wilting was mild, moderate, or severe. A few other measurements indicated that infected uprights may be less permeable than control uprights, even when not wilted.

The rate of CO₂ uptake in the light was measured on the second youngest, fully expanded leaf of one pair of control and infected uprights, while neither upright was wilted. The measurements were made during the morning of August 5. During the preceding 16-hr period, the control upright had lost 44 g, the infected upright 14 g. The carbon dioxide uptake for the control upright was 5 times that of the infected upright.

DISCUSSION

The experimental results indicate that the ratoon stunting disease is implicated in severe wilting of infected Sudangrass hybrid uprights. The following results support this view:

- 1) The symptom follows inoculation with the RSD-virus.
- 2) The RSD-virus may be shown to be present in the progeny of virus-inoculated cuttings by assay for virus on sugarcane.
- 3) The virus, whether from sugarcane or from Sudangrass hybrid, produces the same symptom in the uprights.

- 4) A heat treatment known to inactivate RSD-virus in vivo eliminates the symptom in progeny grown as uprights.
- 5) As would be expected from the behavior of the ratoon stunting disease in sugarcane, there is no indication of vector-mediated spread when infected and control uprights are grown in the same pot.
- 6) The absence of severe wilting in infected plants not grown as uprights suggests the well-known tendency of the ratoon stunting disease toward latency in symptom expression.

The wilting of the aerial stool of infected uprights suggests that the supply of water is inadequate. Other lines of evidence which indicate that a decreased supply, rather than a decreased demand, led to a decreased loss of water from infected uprights are as follows:

- 1) The loss of water from the infected uprights is reduced, even though the plant is continuing to grow. The reduced quotient of the weight of water lost per unit fresh weight (Table 1) indicates this directly. The quotient underestimates the reduction because the fresh weight of some of the infected stools is based on wilted tissue. In several of the plants, the decrease in water loss occurs during the vegetative phase of growth, while in others it spans the period of flowering. Such changes in water demand would be most unusual, and they are contrary to the increased demand of the control uprights.

- 2) The progressive pattern of wilting of infected uprights, including the earlier wilting during the day and the later wilting in the evening, is typical of plants experiencing drought.

- 3) The water loss from infected uprights tends to follow the incident energy curve (Fig. 1). Coupled with this tendency is the lesser relative loss of water from infected uprights compared to control uprights in the afternoon than in the morning. This pattern suggests a more stringent conservation of water rather than a changed demand.

- 4) Infected plants, plants grown from single-node cuttings taken from the chronically wilted stalks of infected uprights, grow and mature normally without showing the wilting syndrome. An alternate pattern of water demand imposed by the disease would not be likely to be fully reversible while the disease persists.

The part of the infected upright responsible for the decreasing water supply has not been directly investigated. The copious bleeding from the sett when the aerial stool was removed, the healthy appearance of the roots, and the well-watered soil suggest that the root system of infected uprights does not limit the water supply. Neither, probably, does the sett; the diameter is small, but the healthy sett can support a large branching stool with many panicles; moreover, the sett is inoculated when fully matured. The infected plants in their normal growth show that a developing shoot need not be adversely affected by the presence of the virus. Experiments with various sugarcane varieties have indicated that quantitative differences in growth, suggestive of physiological drought, can be induced in a RSD-infected upright or a branch of an upright (1). These uprights have one region of attachment of aerial stool to sett; and the branch of an upright has the equivalent of two in series. Results suggest that any reduction in efficiency in water transport in the small region of attachment is very much magnified in the effect produced on growth.

The severe wilting of some shoots and the turgidity of others on the same infected upright suggest that the shoots compete on a winner-take-all basis for a limited supply of water. The recovery noted among axillary shoots, where a shoot which has been wilted will become turgid and grow only to wilt again, favors this competition concept.

It has been repeatedly shown that transpiration and photosynthesis are related through the mutual dependence on the stomatal mechanism for the diffusion of gases. As water loss decreases, net photosynthesis decreases (4). The anomalous situation of the infected upright is that while the aerial stool is wilting, the roots and the sett are amply supplied with water. The continued demand of the tops and growth of the roots may lead either to starvation or to a lowered resistance to secondary infection. Whether one of these mechanisms, or the virus itself, is responsible for the death of the infected upright remains to be determined.

ACKNOWLEDGEMENT

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TABLE 1. Water loss as a function of the fresh weight of the aerial stool for 9 pots each of RSD-infected and control uprights. 1/

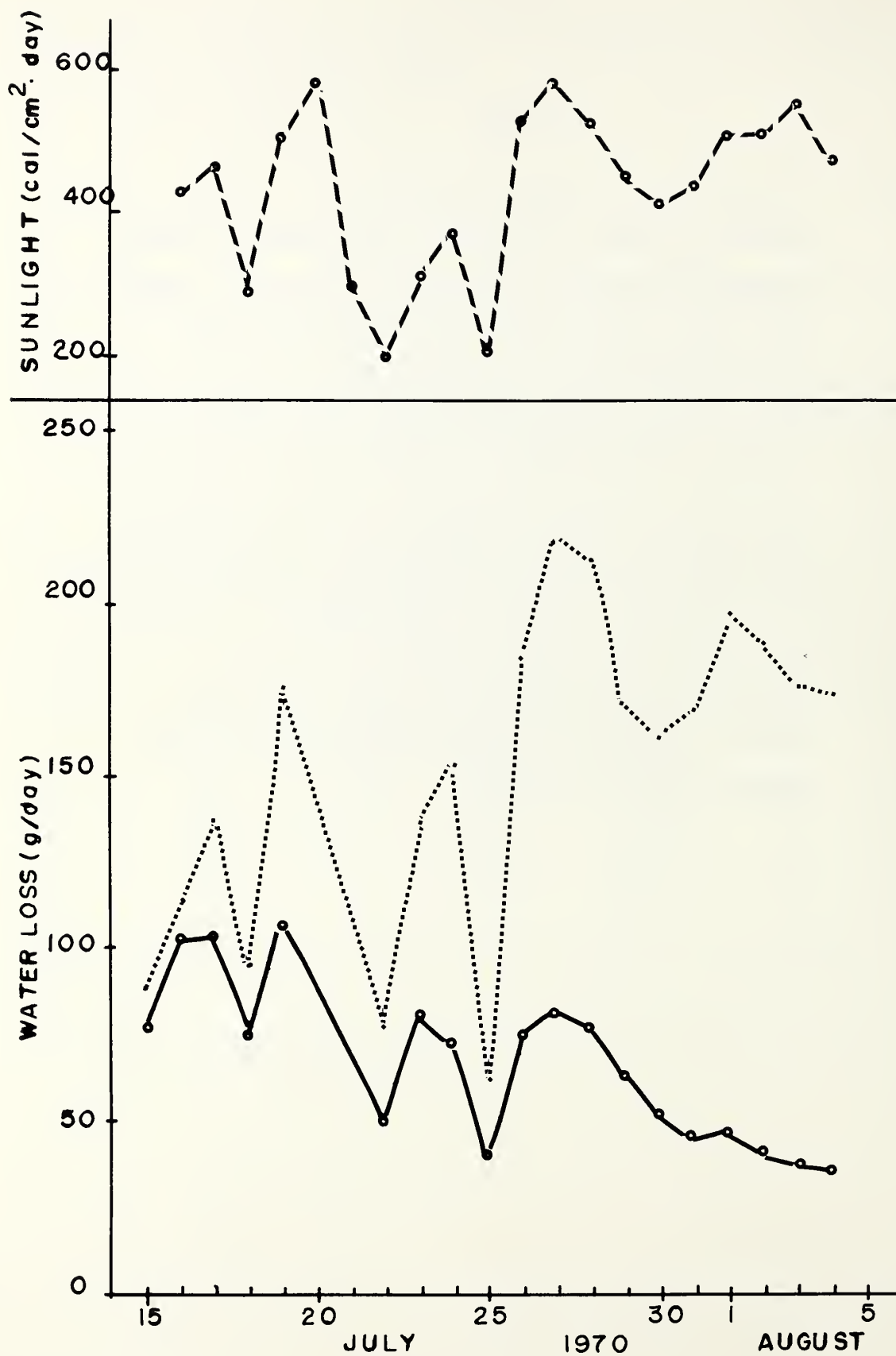
Paired Pots (Set)	Control			Infected		
	Fresh weight (g)	Water loss (g)	<u>Water loss</u> fresh weight	Fresh weight (g)	Water loss (g)	<u>Water loss</u> fresh weight
A	77.4	165	2.13	80.7	78	0.97
B	82.7	173	2.09	61.4	62	1.00
C	73.8	166	2.25	21.5 <u>2/</u>	8	0.37
D	75.3	168	2.23	74.5	58	0.78
E	94.3	186	1.97	35.9 <u>2/</u>	15	0.42
F	73.3	164	2.24	39.7 <u>2/</u>	16	0.40
G	62.4	140	2.24	34.0 <u>2/</u>	9	0.26
H	115.7	246	2.13	63.0	56	0.89
I	70.1	154	2.20	44.6 <u>2/</u>	18	0.40
Average:	80.6	173.6	2.16	50.6	35.6	0.61

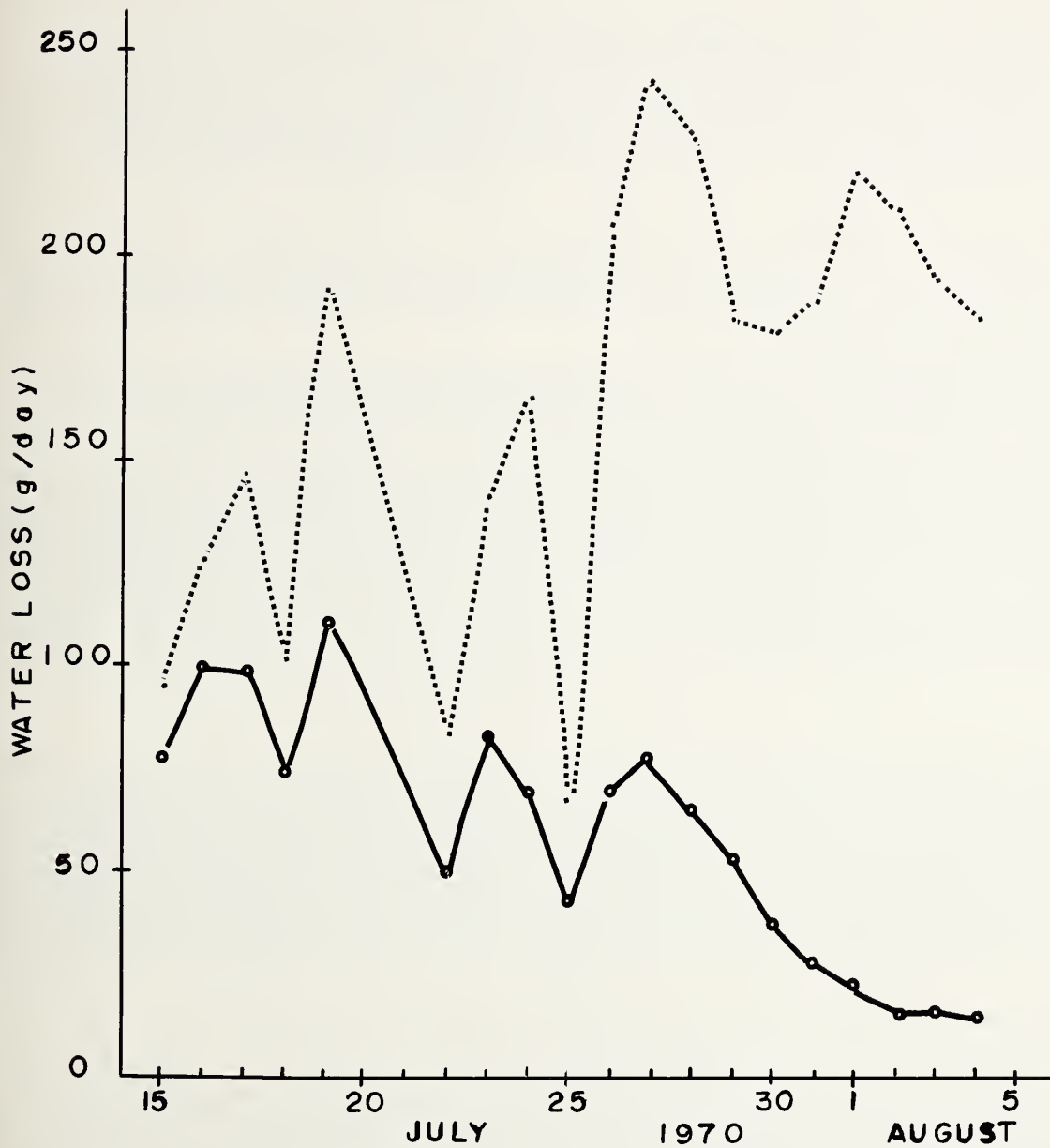
1/ Water loss for the 24-hr period 3 to 4 August, 4:30 to 5:30 p.m. Fresh weight of stool determined August 6.

2/ Main shoot chronically wilted, infected upright of C from July 20, of E from August 1, of F from July 31, of G from July 26, of I from July 25.

Legends

- Fig. 1. The progression of sunlight and of water loss for 24-hr. periods for 3 weeks. Top curve: Incident energy of sunlight as measured by an outdoor radiometer. Lower curve: Average water loss of 9 RSD-infected uprights (solid line) and of their 9 control uprights (stippled line).
- Fig. 2. Water loss from an RSD-infected upright (solid line) and from its control (stippled line) as measured daily at 5 p.m. On both uprights, the flag leaf appeared on July 22; the panicle began emerging on July 27, and by July 30, the panicle was mostly (infected) or entirely (control) emerged. On August 1, the main shoot of the infected upright, but not the axillaries, wilted chronically; its panicle was still not entirely emerged when the experiment was terminated. These uprights are Pair E of Table 1.





STRAINS OF SUGARCANE MOSAIC VIRUS IN FLORIDA

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Sugarcane mosaic virus (SMV) is now rarely found in commercial sugarcanes in Florida. The virus is common in corn and wild sudan-like sorghums, and is found frequently in St. Augustine and other grasses. When noble sugarcanes were grown in experimental plots at Canal Point they could be kept free of mosaic only through constant roguing and replanting. Some varieties that are considered very susceptible to mosaic in Louisiana are rarely found naturally infected in Florida, but there are commercial types that would be massively infected with mosaic if they were grown commercially. It is evident that a certain minimum level of mosaic resistance is essential for commercial canes. It is also evident that this level is substantially below that required in Louisiana. The reasons for this are not known, but they are of considerable interest, and their discovery could have economic consequences for both the Florida and Louisiana sugar industries.

Fluctuation in the importance of mosaic in Louisiana has been clearly related to the interplay of strains of the virus and varieties of cane being grown (1, 2, 6). The noble canes, upon which the industry was founded, succumbed in the 1920's to what is believed to have been strain E. Upon the introduction of hybrid canes, strain E disappeared and was replaced by other strains. Resistant C.P. canes eventually brought mosaic under control, but following the advent of strain H in the 1950's, the disease again became an important problem in the state.

The kind of information that is available about strains of SMV in Louisiana is not available for other areas. The purpose of this paper is to report the results of collecting and typing strains of SMV in southern Florida over the past 5 years.

Strain identifications were made on the sugarcane differential varieties, CP 31-294 and CP 31-588. Many of the collections were studied also in other hosts, principally varieties of sorghum. A few of the collections were clearly none of the mosaic strains known in Louisiana. Some description of the effect of these isolates on the sugarcane differentials is given to document the claim that they differ from described strains, but no formal description or permanent strain designation is intended.

Of 140 isolates of SMV, 121 were typed as strain E, two as strain A, three doubtfully as strain D, one as strain H, and 13 as undescribed.

Strain E.

The overwhelming majority of isolates from all sources were identified as strain E. This is remarkable since strain E apparently disappeared from Louisiana almost 30 years ago (2). Its disappearance there was associated with the change from noble canes to hybrids. In Florida the only strain identified in the past 5 years from noble canes has been strain E. However, noble canes are little grown in Florida; even the nobles of the World Collection have now been moved to a greenhouse in Beltsville, Maryland. Therefore little mosaic is found in sugarcane in Florida. Most of the mosaic occurs in corn and wild sudangrass. These hosts are susceptible to all strains of SMV. Nevertheless, the great majority of isolates even from corn and sudan prove to be strain E. All collections from St. Augustine-grass have so far been identified as strain E, although this grass can be infected artificially by other strains.

The disappearance of strain E from Louisiana with the lapse of the noble canes and its overwhelming prevalence in Florida in the absence of noble canes is not presently explainable.

Because of the known variation within strains of SMV (2), it is apparent that the prevalent SMV in Florida is not necessarily identical with the original strain E in Louisiana. However, this virus varies in no detail from the description of strain E provided by Summers, Brandes, and Rands (5) as far as that description goes. Some additional observations can be made but there is no apparent basis for differentiating the one virus from the other. The original strain E was primarily a pathogen of noble canes. In leaves of CP 31-294 it produced discrete spindle-shaped, chlorotic lesions partially or completely surrounded by red borders. Occasionally very striking red patterns were associated with the chlorosis. Growing plants of CP 31-294 tended to recover from strain E. The virus was non-infective on most hybrid canes. Strain E was the only strain producing no measurable stunting of CP 31-294. All of this description applies to the Florida virus. It may be added that the peculiar, discrete, sparse, chlorotic lesions observed by Summers, and the tendency of CP 31-294 to recover, are not independent phenomena. Both are effects of a tendency for the virus to remain localized. This probably also

explains the lack of stunting. Occasionally in the early stages of infection of young CP 31-294 plants, the mosaic pattern may involve almost all of the leaf area of the plant, in which case it is not clearly distinguishable from symptoms of strain D infection. This condition does not always occur, and in any case it is temporary. It is soon followed by a thinning out of the pattern into discrete, elongated or spindle-shaped, chlorotic lesions. There may be many or as few as one such lesion per leaf. Often the number of such lesions progressively declines on successive new leaves until the plant completely recovers. This recovery sequence may be observed more readily and with greater reliability in Rio sorghum. Recovery of the youngest leaves in Rio is usually complete within 2 weeks after the first symptoms appear. In both Rio and CP 31-294 the red discoloration is an inconstant character. Casual observation indicates that lower temperatures favor the red discoloration. Under low temperature conditions, the virus may produce red-bordered chlorotic lesions on the inoculated leaves but never become systemic.

In Rio, at least, recovery appears to result from increasing resistance to systemic movement of the virus with increasing age of the host. If inoculation of seedlings is delayed until after the normal age of recovery (3 to 4 weeks), no systemic symptoms develop although the virus may be recoverable from the inoculated leaves up to the time the leaves wither and die. If inoculation occurs at the age of transition from susceptibility to resistance, the first symptoms are recovery-phase symptoms (i.e. sparse, isolated, chlorotic lesions), and recovery follows immediately. The next new leaf unfolded after the leaf on which first symptoms appear is likely to be symptomless. In CP 31-294 the virus apparently is never able to survive indefinitely, although complete recovery has required more than 1 year in extreme cases.

The reaction of CP 31-588 to strain E is essentially the same as that of CP 31-294 except that the virus seems to have even greater difficulty becoming and remaining systemic.

Strains A and D

Two collections were identified as strain A and three as strain D. The isolates of strain A produced mild mosaic symptoms in both CP 31-294 and CP 31-588 with no necrosis in either host. Characteristic short, whitish or yellowish lines in the mosaic pattern on leaves of CP 31-588 clearly indicated classification as strain A. The classification of three isolates as strain D was less clear cut. The tendency toward longitudinal streaking in the mosaic pattern supposed to be characteristic of strain D in CP 31-294 was not present with two of the isolates but was a prominent feature of the third. However, the isolate showing the typical strain D mosaic pattern produced only a trace of necrosis, only slight stunting, and no killing of growing points or excessive tillering. The two isolates lacking the typical strain D mosaic pattern produced considerable necrosis, severe stunting, extensive killing of growing points, and excessive tillering. Two of these isolates, those lacking the strain D mosaic pattern, came from corn, and the third came from naturally infected P.O.J. 213 sugarcane. The three isolates clearly represented two types, but both of these seemed to fall within the range of variability permitted for strain D by Abbott and Tippet (2). Admittedly the two types could have been considered two undescribed strains.

Strain H

One isolate from corn gave symptoms typical of strain H on CP 31-588, i.e., a very mild mosaic pattern without the short whitish lines that distinguish strain A from H on this host. Attempts to transmit this isolate to CP 31-294 failed repeatedly. According to Abbott and Tippet (2), 80% of Louisiana isolates of strain H do not infect CP 31-294. Strain H is very aggressive in Louisiana and its appearance was accompanied by a marked change in the mosaic status quo (1). No such change has occurred in Florida. There is no particular reason for thinking this strain was new in Florida when it was collected in 1968. That this isolate is identical to the aggressive strain H of Louisiana seems doubtful, but under the current system of defining strains, it clearly must be regarded as strain H.

Undescribed Strains

The second most frequently collected strain was designated Sud for this report simply because it was first collected from Sudangrass. Later it was also collected several times from sweet corn. Nine isolates of Sud were collected over a period of 5 years. This strain could be considered as intermediate between strains A and B with regard to symptoms in CP 31-294. The mosaic pattern is much too severe for strains A or H, but it lacks the necrosis required for strains B or D. It also lacks the bleached effect at the base of young leaves that is typical of strain B, and the streaked effect typical of the pattern produced by strain D. It is very infective on Mn 1054 sorghum which is only lightly infected by other strains of SMV in Florida except strain A. One isolate classified as Sud was highly infective on Mn 1054 sorghum when first isolated but later was found to be essentially non-infective on this host. Its symptoms on CP 31-294 had not detectably changed. It is apparent then, that at least two types are lumped here, but they cannot be separated on the sugarcane differential hosts commonly used.

Two isolates of SMV from Sudangrass gave an ordinary mosaic pattern on several sorghums and was very highly infective to sorghums. They failed repeatedly to infect the sugarcane differentials and Johnsongrass seedlings or clones. After repeated failures, a low percentage of P.O.J. 234 and Branchue (a noble cane) plants were infected. The symptoms were very mild and late in developing.

These isolates also gave mild, delayed symptoms with a low percentage of infection in Golden Bantam sweet corn. These isolates are clearly different from any known strain of SMV or maize dwarf mosaic virus (MDMV).

Two isolates from corn could have been classified as strain B if they had produced the bleaching at the bases of young leaves of CP 31-294 and more necrosis. They differ from Sud in that they give more necrosis and stunting, and from D in that they failed to give the streaked mosaic pattern and killing of growing points. These isolates were first classified tentatively as strain B and perhaps they could be considered as a variant of B. However, Abbott and Tippet (2) apparently regard the bleached effect at the base of young CP 31-294 leaves as an essential character of strain B.

DISCUSSION

The survival of strain E in Florida after the disappearance of the noble canes contrasts sharply with its behavior in Louisiana where it disappeared simultaneously with the noble canes. The discovery of strain H in Florida without the accompanying changes in the mosaic problem in commercial canes as occurred in Louisiana with the appearance of strain H is also puzzling. Obviously, many explanations that might account for these facts are possible. One of these is variability within strains as presently defined. At least two types of strain H, differing in host range are known to occur in Louisiana (2). There could be a third type in Florida lacking the aggressiveness of Louisiana's strain H's.

In the work reported here, no variability has been observed in strain E. However, this may be largely accidental. The best way to reveal variability within strains is to sort isolates by more than one method. Typing the Sud strain on CP 31-294 sugarcane and Mn 1054 sorghum revealed two types of Sud. Three methods could have been used for identifying strain E, but in fact only two were used for any appreciable number of isolates. The production of local lesions on Atlas sorghum was not used as a typing procedure because very infective inocula were required to produce a useful number of lesions, and collections from the field often yield inocula of low infectivity. Consequently, the reaction of Rio sorghum was used as an alternate means of typing strain E. Oddly enough, except for variation in timing, the reaction of Rio is almost identical to that of CP 31-294. Possibly the same genetic information in the virus is responsible for the reaction in both hosts. This could account for the remarkable agreement between the two methods of identifying strain E.

Evidence for variability within strain E has been found by Saladini (5). He found a significant difference in insect transmissibility between two isolates of strain E, one which had been maintained as a stock culture in the greenhouse for several years, and the other recently isolated from the field. Both viruses typed as strain E on differential hosts.

Although the SMV isolates discussed in this report were classified (to some extent arbitrarily) as belonging to seven different strains, two types of strain D were distinguishable on CP 31-294, and two types of Sud were distinguishable when Mn 1054 sorghum was used as an additional differential host. Saladini worked with two types of strain E distinguishable on the basis of insect transmissibility. Thus, with relatively little investigation in a small area of Florida, at least 10 "strains" of SMV were shown to be present. Probably half of these, and possibly all of them, represent types that were never known in Louisiana. MDMV, which is relatively new in the United States, is already being shown to exist as a series of strains (4, 7). Variability in this group of viruses is obviously great, and it is apparent that the strains of SMV as defined on sugarcane differential hosts are groups of strains or substrains. It is clear that they could be further subdivided by use of other criteria. Abbott and Tippet (2) noted this but felt that endless multiplication of strains seemed pointless. According to Abbott and Tippet changes in the prevalence of strains of mosaic (as defined on cane differentials) correlates well with changes in resistance of cane varieties to spread of mosaic. This seems to indicate that from the viewpoint of plant breeding, the system of strain identification used in Louisiana has been adequate. However, sugarcane breeding programs in Louisiana have been plagued in some degree by an apparent lack of correlation between the results of mosaic resistance testing in the greenhouse and mosaic resistance exhibited in the field. This may in part be due to variability within strains. In Mississippi when the plants were exposed to the same isolate of mosaic in both greenhouse- and field-resistance testing, no such lack of correlation between field and greenhouse results was noted (3).

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RATOON STUNTING DISEASE VIRUS: PROBLEMS IN PURIFICATION

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ABSTRACT

A major problem in obtaining a pure preparation of the virus of the ratoon stunting disease of sugarcane is the close association of the virus with particles of host origin. Sugarcane leaf juice contains contaminants different from those in stalk juice, but no better purification has been achieved by using leaves. Several possibilities exist for separation of virus from contaminants without inactivation of the virus. Clarification by pH precipitation, freezing and thawing, and celite filtration are methods which can aid in this separation whereas polyethylene glycol, antibodies against normal plant antigens, chloroform, and n-butanol are not useful. Some separation of the virus from contaminants is also achieved with density gradient centrifugation and density gradient electrophoresis, but agar-gel filtration does not aid separation. The biological assay method, using CP 44-101 cuttings and juvenile symptoms, is the best, thus far, since it gives a rapid indication of differences in virus concentration.

INTRODUCTION

This paper will discuss attempts to obtain further purification of the virus and will include a summary of the problems encountered with these purification attempts.

The ratoon stunting disease (RSD) was first recognized during the summer of 1944-45 in Queensland, Australia (12). For the next 20 years, research to characterize the causal agent was hindered by the absence of an adequately rapid method to detect biological activity of the virus (12). In 1966, a method (5) was reported which used immature stem symptoms in plants from single-bud cuttings inoculated 4 to 6 weeks before; the cuttings are prepared from stalks of sugarcane (*Saccharum* hybrid CP 44-101). Previously, the most rapid assay technique required 2.5 to 6 months (9). More recently, an assay technique, also requiring only 4 to 6 weeks but using Co 421 instead of CP 44-101, was reported (10).

Many unsuccessful attempts have been made to purify the ratoon stunting disease virus (RSDV) (2, 7, 12). One method has been reported for a partial purification of the virus (5). This method consists of celite filtration of juice from RSD-infected sugarcane stalks followed by two cycles of differential centrifugation, a freeze-thaw step, and one or two sucrose rate density gradient centrifugations. The resulting preparation contains RSDV-infectivity and also material of host origin.

MATERIALS AND METHODS

RSDV was usually obtained from mature sugarcane plants grown in an insect-proof greenhouse. Field-grown plants were used on some occasions, especially as sources of leaves for purification.

The infected juice was usually obtained from stalks of CP 44-101 grown as progeny from RSD-infected plants. Tissue for purification was ground in a laboratory mill and the juice expressed in a Carver press. The juice was clarified (to remove a large amount of host material) in one of several ways to be described in the next section.

A Spinco Model L ultracentrifuge ^{1/} was used for high speed centrifugation; typical schedules included 30,000 rpm (78,000 g) for 2 hr by using a No. 30 rotor; 38,000 rpm (95,000 g) for 1.5 hr by using a No. 40 rotor; or 45,000 rpm (122,000 g) for 1-1.5 hr by using a No. 50 rotor. For low speed centrifugation, either 10,000 rpm (8,700 g) for 10-15 min using a No. 30 rotor on a Spinco Model L centrifuge or 5,000 rpm (4,000 g) for 15-30 min by using a No. 822 a rotor on an International Refrigerated Centrifuge ^{1/} was used.

Linear sucrose gradients for rate and "equilibrium" density gradient centrifugation were prepared using an automatic gradient mixer. Gradients for rate (zonal) centrifugation were prepared from 12.5 ml each of solutions containing 100 and 400 g sucrose/liter. Gradients for equilibrium centrifugation were prepared from 10 ml each of solutions containing 200 and 600 g sucrose/liter. Both for rate density gradient centrifugation, 21-23,000 rpm (45,000-56,000 g) for 2-2.5 hr, and equilibrium density

^{1/} Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the USDA, and does not imply its approval to the exclusion of the other products that may also be suitable.

gradient centrifugation, 20,000 rpm (41,000 g) for 17 hr, a swinging bucket rotor (SW 25.1) was used.

After centrifugation, the gradients were fractionated in one of two ways. When a more rapid separation and a lower quality fractionation was desired, the tube was punctured with a hypodermic needle just below the area or band and a sample was withdrawn with a syringe. For more accurate fractionation and when a UV-scan was required, an ISCO Model D fractionator with a Model UA-2 Ultraviolet Analyzer 1/ (254 nm) was used.

Tiselius electrophoresis with a Perkin-Elmer Model 238 Electrophoresis Apparatus 1/ was used. Tiselius electrophoresis was carried out in 0.1 ionic strength sodium phosphate buffer at pH 7 and with a current of 15 ma. Density gradient electrophoresis was done in a Steere-Davis Electrophoresis Apparatus 1/ on a linear gradient of 0.6M to 2 M sucrose dissolved in borate buffer, pH 8.6. Density gradient electrophoresis was carried out at about 10°C for 20-24 hr at 330 volts and 10-50 ma.

Biological activity was determined by inoculating cuttings prepared from stalks of CP 44-101 grown in in 4-gal buckets in an insect-proof greenhouse. The stalks were derived from heat-treated (50°C for 2 hr) cuttings. Single-bud cuttings, 5-8 cm long, were inoculated by dipping the cut ends in the virus suspension (5). At least 20 cuttings were used for each sample and for the noninoculated control. Cuttings were grown in flats of vermiculite for 4-6 wk after inoculation, and the internal tissue of the young stems was then examined for juvenile symptoms of RSD (12).

RESULTS AND DISCUSSION

Infectivity assay

An adequate method for determining virus infectivity is essential for the development of purification methods and for studies of virus properties. The method of using CP 44-101 single-bud cuttings and juvenile symptoms gives the most rapid results of any test tried (4-6 wk). In this test, the percent infected is indicative of differences in virus concentration (Fig. 1).

Several problems arise with this method. Maintenance of large numbers of heat-treated plants, which must be kept free of disease and borers, is expensive. In the assay it is difficult to obtain even germination and development of plants. The variability in growth contributes to the proportion of plants in which the symptoms cannot be read with certainty.

Some of these problems could be avoided if there were an assay host that could be grown from true seed. True seed is likely to prove free of virus, to store readily, and to germinate evenly. The search for such a host plant for assay use continues.

Virus sources

One approach to purification of RSDV is to find a better source of virus than the stalk juice of infected sugarcane. Most of the work in Louisiana has been done with stalk juice of CP 44-101, and some with stalk juice of N Co 310. Some other part of the cane plant or some other host plant might be a better source. Other parts of the sugarcane plant might yield contaminants more easily eliminated than are those from the stalk. Similarly, juice properties of another host plant could present contaminants more easily eliminated than those from sugarcane.

Since sugarcane leaves contain a large amount of RSD-infectivity (2, 4, 12), attempts were made to purify RSDV from leaves of CP 44-101, Co 453, Cl 41-223, and M 336 with the celite filtration method (5) and with some modified clarification methods. Some of these partially purified preparations were infectious, but the virus was associated with host contaminants, including pigments not present in the stalks. Work with leaves as a virus source continues.

Host plants other than sugarcane were studied as virus sources. Stalk juice from an infected sudangrass hybrid was found to be an unsatisfactory virus source compared to CP 44-101 stalk juice. It contained too low a virus titer. Work is in progress with other hosts; Sorghum bicolor [L.] Moench, cv. 'Rio' seems to contain a higher virus titer than the sudangrass hybrid.

Clarification methods

Many methods have been tried for clarifying RSD-infected juice. All of the methods discussed below pertain to clarification of sugarcane stalk juice except where noted. Celite, celite plus activated charcoal, calcium phosphate gel, and bentonite give adequate clarification of CP 44-101 stalk juice (5). Celite was used routinely as it produced more consistent and higher virus yields.

Celite alone did not clarify leaf juice as well as it did stalk juice, and the preparations contained a lot of pigment. The pigment was not eliminated by the addition of absorbic acid, 2-mercaptoethanol, or sodium diethyldithiocarbamate, singly or in combination, to the leaf juice after grinding in a laboratory mill and before celite filtration. When leaves were ground in a blender in one of the above solutions and then filtered through celite, the pigment content of the preparations was reduced, but the preparations contained little virus infectivity.

Early results showed that n-butanol and chloroform, either together or separately, reduced infectivity. Chloroform alone reduced infectivity less, but the clarification was no better than with

celite. Ammonium sulfate destroyed the infectivity and heating the juice at 40°C for intervals up to 68 min (1) failed to clarify the juice.

Freezing and thawing of the preparation after the second high speed centrifugation caused a large amount of impurities to sediment at low speed (5). However, freezing and thawing of raw juice or celite filtered juice produced little clarification.

When the raw stalk juice is adjusted to pH 7, a large precipitate is formed and low speed centrifugation gives fair clarification. However, when disodium (ethylenedinitrilo) tetraacetate (EDTA) is added to a final concentration of 0.01M, and then the pH is adjusted to 7.0, no precipitate is formed. The addition of EDTA to leaf and stalk juice gives a sample which can be filtered more rapidly through celite, but it does not aid clarification. In contrast to sugarcane mosaic virus preparations from sugarcane leaves (8), adjusting the pH of samples after centrifugation to about 5.0 does not aid clarification.

Some plant virus preparations have been clarified by use of antibodies to normal plant antigens (3). One-year old sugarcane seedlings, known to be disease-free, were processed in the same manner as infected cane through the second high speed centrifugation step. These preparations were injected into rabbits intramuscularly (with an occasional intravenous injection) at 1-2 wk intervals for 1-1.5 months. The rabbits were then bled at one week intervals for one month. The antiserum so produced was used to absorb infectious preparations. Alternatively, the gamma-globulin fraction of the antiserum to healthy seedlings was separated and used to absorb infectious preparations. Neither method was successful, and each reduced infectivity. The virus may be closely associated with particles of host origin and be removed along with the host antigen.

Polyethylene glycol 6000 (PEG) has been used successfully to clarify preparations of plant viruses (6). When RSD-infected leaf or stalk juice was filtered through celite and treated with 4% PEG-NaCl and centrifuged at low speed, most of the infectivity sedimented. After the pellet was resuspended and centrifuged at low speed, most of the infectivity again sedimented, indicating that RSDV is closely associated with materials of host origin. PEG-treatment of preparations which had not been filtered through celite, or which had been prepared through the high speed centrifugation step, gave similar results.

Ultracentrifugation methods

Differential ultracentrifugation (alternating low- and high-speed centrifugation) was used after clarification to concentrate the virus and eliminate some of the contaminants. The loss of virus which occurs during this procedure is a major obstacle to successful RSD-purification. Much of the virus remains in the low-speed pellets. Phosphate, citrate, and borate buffers (with a total additive range of pH 5-9) and boiled sugarcane juice were tested as agents which might disassociate the virus from the contaminants. None of the buffers tried have given satisfactory results, but the search continues.

Differential centrifugation followed by rate sucrose density gradient centrifugation gives some further separation of virus from contaminants; however, the virus infectivity is not restricted to a narrow band, although most of the infectivity is concentrated in a visible band at about 1.3 cm below the meniscus of the gradient. Infectivity is associated with material below the 1.3 cm band. This suggests aggregation of virus particles or association of virus with particles of more than one general size.

When rate density gradient centrifugation was followed by "equilibrium" sucrose density gradient centrifugation (17 hr at 20,000 rpm), no further separation was noted (1). Cesium chloride gradient centrifugation (34,000 rpm for 24 hr on a SW 39 rotor) following rate density gradient centrifugation caused denaturation and loss of infectivity.

Gel-filtration and electrophoresis

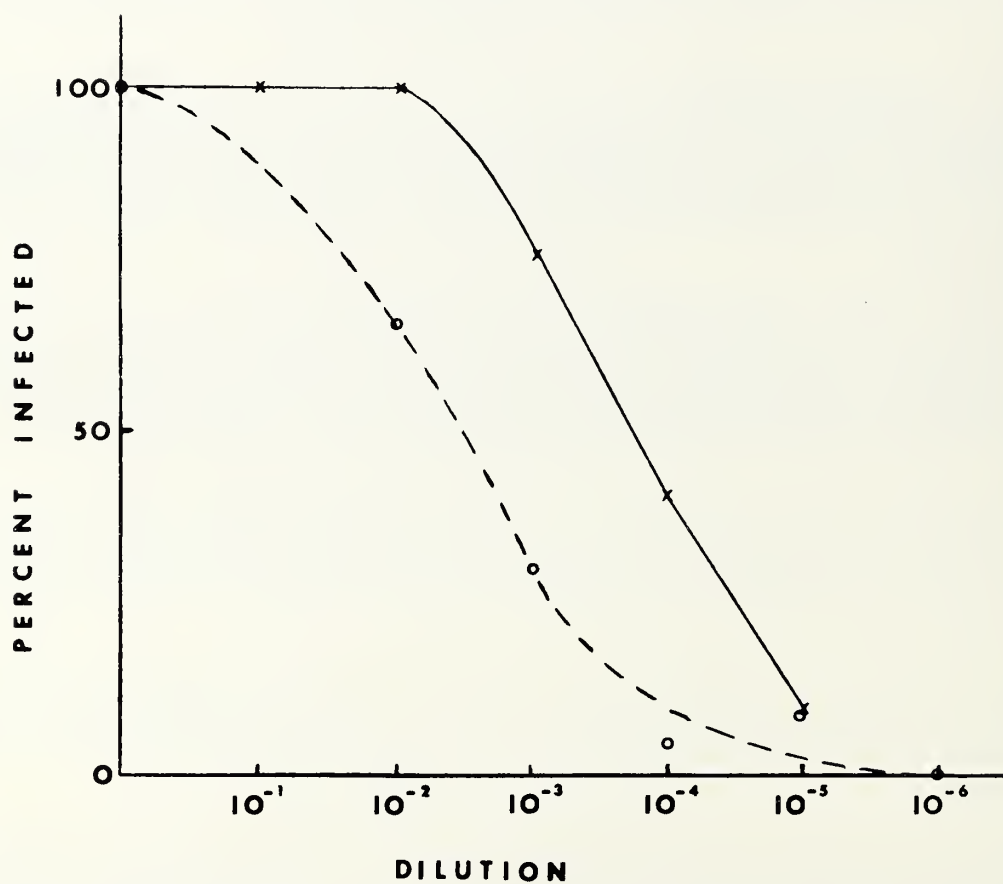
Filtration using agar or agarose gel columns (11) following either differential or rate sucrose density gradient centrifugation did not give satisfactory separation, nor did many infectious particles pass through the columns. This suggests either aggregation of the virus or its association with particles producing complexes too large to move through the agar column.

A promising method being investigated is separation by electrophoresis after differential or density gradient centrifugation. Tiselius electrophoresis of partially purified RSDV preparations indicated the separation of 2-3 different moieties. Tiselius electrophoresis is primarily an analytical method, and although some separation of non-infectious and infectious particles was done by Tiselius electrophoresis, density gradient electrophoresis is a more practical purification technique. Preliminary data with density gradient electrophoresis indicate that this method may prove to be an important step in separating RSDV from at least some of the host contaminants.

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Figure 1. Assay of biological activity of RSD-infected CP 44-101 stalk juice. For test 1 (x) percent infection based on 17-20 plants and test 2 (o) based on 37-44 plants. Dilutions made in distilled water.



INFLUENCE OF STRAINS OF SUGARCANE MOSAIC VIRUS ON
STANDS, STUBBLING ABILITY AND YIELDS OF SUGARCANE VARIETIES

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ABSTRACT

The separate effects of sugarcane mosaic virus (SCMV) strains A, H, and I on stands and yields of plant and first stubble crops of the commercial varieties L 60-25, CP 48-103, and CP 61-37 were compared in a replicated field test. Strain I, a recently identified strain in Louisiana, produced effects on stands, stubbling ability and yields more severe than those of strain H, the most prevalent SCMV strain in Louisiana. Strain H produced effects more severe than strain A, which did not differ in yields from the healthy control.

INTRODUCTION

Sugarcane mosaic virus (SCMV) strains A, B, D, and H were the only strains isolated from commercial sugarcane fields in Louisiana since 1950 (1), until a new strain, designated strain I, was reported by Tippet and Abbott in 1968 (6). This strain was observed to stunt the growth of commercial varieties more than the other strains. The stunting, together with field observations of severe mosaic symptoms on all collections identified as strain I, suggested that this strain might cause greater injury than strain H to sugarcane varieties. Greenhouse inoculations by Breaux and Dunckelman (2) showed that sugarcane varieties differ in their susceptibility to infection with SCMV strains B, H, and I.

The objective of the field test reported here was to compare the separate effects of SCMV strains A, H, and I on the stands, stubbling ability, and yields of plant and stubble crops of the commercial varieties L 60-25 (susceptible to mosaic), and CP 48-103 and CP 61-37 (both moderately resistant to mosaic). The results from the plant crop were reported earlier (7). Secondary infection and contamination were minimal, so the experiment was extended to include stubbling effects. The test was located at the U.S. Sugarcane Field Station, Houma, Louisiana.

MATERIALS AND METHODS

The experimental procedures of the test were described in detail elsewhere (7). The test was of a simple factorial design, and the four treatments (healthy and 100% infected with SCMV strains A, H, or I) for each variety were replicated four times. Each plot consisted of three 15 ft-long rows (1/173 acre). Standard plantation practices for planting (two stalks and a 10% lap), fertilization, cultivation, and weed control were followed.

The test was planted on September 24, 1968. The plant and first stubble crops were hand-harvested on November 26, 1969 and November 5, 1970, respectively.

The following determinations were made for each crop: (i) primary shoot counts in late April; (ii) percent of all shoots with mosaic symptoms in mid-June; (iii) millable stalk counts in November; (iv) tons of cane per acre; and (v) pounds of sugar per acre. Plot weights of cane were obtained in the field after the trash was burned from the cane; the weights were converted to tons per acre. Fifteen-stalk samples were taken from each plot for Brix and sucrose analyses. Some of the data from the two crops were subjected to combined analyses, while some data for the two crops are presented separately.

RESULTS AND DISCUSSION

The percentages of mosaic-diseased shoots in mid-June for the plant and stubble crops are presented in Table 1. The healthy controls of CP 48-103 and CP 61-37 were free of mosaic in the plant crop; CP 48-103 remained free of mosaic in the stubble crop, while the incidence of mosaic in the stubble crop of CP 61-37 was less than 0.5%. Two % and 9% of the shoots of L 60-25 plant and stubble crops, respectively, became naturally infected with mosaic. There was little natural spread of mosaic within the test.

With the exception of plant crop CP 48-103, which was 68% diseased, all three varieties initially 100% infected with strain H remained completely infected in plant and stubble crops. The percentages of shoots infected with strain I in the plant and stubble crops of CP 48-103 were much lower (47% and 55%, respectively); the shoots of L 60-25 were completely diseased in both crops; CP 61-37 had a higher

percentage of diseased shoots in plant crop (84%) than in stubble crop (60%). The proportion of diseased shoots from seedcane infected with strain A was considerably lower than from that with other strains for all three varieties; CP 61-37 had the lowest percent of mosaic-diseased shoots for both plant and stubble crops (8% and less than 0.5%, respectively).

The tendency of some varieties (e.g. CP 48-103 and CP 61-37) to recover from strain A was observed by Benda (unpublished data) in greenhouse studies of mosaic recovery. Benda also observed CP 61-37 to recover from strain H, but to a lesser degree than from strain A. He observed no recovery of CP 48-103 from strains H and I. Our results indicate no field recovery of CP 61-37 from strain H, but recovery from strains A and I. CP 48-103 shows field recovery from strain I.

Under field conditions, some factors (e.g., cool night temperatures) may influence recovery of some varieties from some mosaic strains, which may not occur in the greenhouse. It is also possible that recovery may take place in some varieties in the greenhouse and not in the field due to other factors (e.g., high greenhouse temperatures).

Recovery of sugarcane from strains of mosaic is determined both by the strain of the virus and the variety of cane (4). Recovery may be accompanied by loss of the virus (3, 4). Thus, even though 100% diseased cane is planted, if recovery is high, measurements may be made on essentially healthy cane. Therefore it is important to determine the number of stalks with mosaic late in the crop.

The number of primary shoots in the spring (Table 2) reflects the ability of the buds or early growth of the seedcane to survive the winter (plant crop) and the stubbling ability of the stubble crop. Strain A did not significantly reduce the shoot counts of both plant and stubble crops of all three varieties. Strain H significantly reduced the shoot counts of plant and stubble crop L 60-25 and stubble crop only of CP 61-37. Strain I significantly reduced the plant crop shoot counts of only L 60-25 and the stubble crop shoot counts of all three varieties; the effect of strain I was greater than that of strain H only in the stubble crop of CP 48-103 and L 60-25.

The number of millable stalks of both plant and stubble crops of all three varieties were unaffected by strain A; strain H caused a significant reduction in the plant and stubble crops of both L 60-25 and CP 61-37. Strain I significantly reduced the number of millable stalks of both plant and stubble crops of all three varieties. The effects of strain I were greater than those of strain H, with the exception of stubble crop CP 61-37, which was similarly affected by both strains.

Combined plant and stubble crop data on the effects of strains A, H, and I on stands (primary shoot counts) in the spring and number of millable stalks in the fall of the three varieties are presented in Table 3. Strain A significantly reduced the stand of only the variety L 60-25. Strain H significantly reduced the stands of L 60-25 and CP 61-37, but not of CP 48-103. Strain I significantly reduced the stands of all three varieties; the effect was significantly greater than that of strain H for CP 48-103 and L 60-25.

The number of millable stalks was not affected by strain A (Table 3). Strain H significantly reduced the number of millable stalks of L 60-25 and CP 61-37 when compared to the healthy control; it caused a significant reduction in CP 48-103, when compared to strain A. The reductions caused by strain I were significantly greater than those caused by strain H in all varieties.

Combined plant and stubble crop data on the effects of the mosaic strains on yields of the varieties are presented in Table 4. Strain A did not significantly reduce the tons of cane or pounds of sugar per acre of any variety. Strains H and I significantly reduced the tons of cane per acre and pounds of sugar per acre of all three varieties; strain I caused a significantly greater reduction than strain H in tons of cane per acre of all three varieties and in pounds of sugar per acre of CP 48-103 and CP 61-37.

Strain I caused the greatest reductions in numbers of millable stalks and yields, followed by strain H, which in turn was significantly more severe than strain A. Numbers of millable stalks and yields of cane infected with strain A did not differ significantly from the healthy controls; this result is not unexpected since, in field experiments, it has generally not been possible to measure significant differences in yield when the rate of infection is less than 50% (5). The incidence of mosaic after recovery from strain A is well within the range where field measurements are not sufficiently precise to detect a difference.

The stubbling ability of CP 48-103 was affected by only strain I, while that of CP 61-37 was affected equally by strains H and I. There was a severe effect of strains H and I on the stands of L 60-25 plant cane crop, and only strain I caused further sizeable reduction in the stands of the stubble crop of this variety.

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TABLE 1. Percentage of shoots recorded with symptoms of sugarcane mosaic (SCMV) in June 1969 and 1970.

:: % Mosaic in plant and stubble crops of three varieties									
:: _____ planted with 100% infected stalks 1/									
Treatments 2/	:: Plant crop-1969 :					: First stubble crop-1970			
	:: CP 48-103:L 60-25:CP61-37:					: CP 48-103:L 60-25:CP 61-37			
Healthy	::	0	:	2	:	0	:	9	Tr.3/
SCMV-A	::	31	:	40	:	8	:	32	Tr.
SCMV-H	::	68	:	100	:	100	:	100	100
SCMV-I	::	47	:	100	:	84	:	55	100 : 60

- 1/ Weighted means of four plots per treatment. Counts of mosaic diseased shoots/total number of shoots made on June 12, 1969 for the plant crop and on June 15, 1970 for the first stubble crop.
- 2/ Healthy plots planted with mosaic-free seed; plots of cane infected with strains A, H, or I planted with 100% infected stalks.
- 3/ Tr = less than 0.5%.

TABLE 2. The effect of sugarcane mosaic virus (SCMV) strains A, H, and I on stubbling ability of three sugarcane varieties.

:							No. of shoots/acre in spring 1/																																																		
:							Plant crop (4/25/69)				:							First stubble (4/23/70)																																							
Treatments:														CP 48-103				:				L 60-25				:				CP 61-37				:				CP 48-103				:				L 60-25				:				CP 61-37			
Healthy	:	6098 a				:	5709 a				:	5839 a				:	13,494 a				:	14,653 a				:	11,678 a																														
SCMV -A	:	6358 a				:	4931 a b				:	4758 a				:	14,221 a				:	11,626 a				:	11,366 a																														
SCMV -H	:	5233 a				:	3417 b c				:	4887 a				:	13,269 a				:	7,560 b				:	6,868 b																														
SCMV -I	:	5233 a				:	3114 c				:	4801 a				:	7,214 b				:	4,066 c				:	5,744 b																														
No. of millable stalks/acre 1/																																																									
:														Plant crop (10/21/69)				:														First stubble (11/ 5/70)																									
Healthy	:	24,869 a				:	27,550 a				:	25,777 a				:	24,912 a				:	33,000 a				:	28,069 a																														
SCMV -A	:	24,653 a				:	24,999 a				:	23,312 a b				:	29,107 a				:	29,886 a				:	29,756 a																														
SCMV -H	:	21,668 a				:	17,300 b				:	19,160 b				:	23,269 a				:	16,997 b				:	19,160 b																														
SCMV -I	:	13,494 b				:	11,678 c				:	13,754 c				:	13,191 b				:	9,991 c				:	15,008 b																														

- 1/ Figures are means of four replicates. Treatment means under any one variety followed by the same letter are not significantly different at the 5% level of probability according to Duncan's multiple range test.

TABLE 3. Effects of sugarcane mosaic virus (SCMV) strains A, H, and I on stand (primary shoot counts) and number of millable stalks of three sugarcane varieties (combined analyses of two crops).

Treatments	Varieties		
	CP 48-103	L 60-25	CP 61-37
<u>No. of primary shoots/acre 1/</u>			
Healthy	: 9,795 a <u>2/</u>	: 10,185 a	: 8,757 a
SCMV-A	: 10,294 a	: 8,282 b	: 8,065 a
SCMV-H	: 9,256 a	: 5,493 c	: 5,882 b
SCMV-I	: 6,228 b	: 3,590 d	: 5,277 b
<u>No. of millable stalks/acre 1/</u>			
Healthy	: 24,889 a b <u>2/</u>	: 30,275 a	: 26,922 a
SCMV-A	: 26,879 a	: 27,441 a	: 26,533 a
SCMV-H	: 22,468 b	: 17,148 b	: 19,160 b
SCMV-I	: 13,342 c	: 10,833 c	: 14,380 c

1/ Primary shoot counts made on April 23, 1969 (plant crop) and April 25, 1970 (stubble crop); millable stalk counts on November 26, 1969 (plant crop) and November 5, 1970 (first stubble crop).

2/ Figures are means of eight replicates (four replicates each for plant and first stubble crops). Treatment means under any one variety followed by the same letter are not significantly different at the 5% level of probability according to Duncan's multiple range test.

TABLE 4. Effects of sugarcane mosaic virus (SCMV) strains A, H, and I on yields of three sugarcane varieties (combined analyses of two crops).

Treatments	Varieties		
	CP 48-103	L60-25	CP 61-37
<u>Tons of cane/acre</u>			
Healthy	: 26.58 a <u>1/</u>	: 28.20 a	: 27.29 a
SCMV-A	: 27.74 a	: 25.20 a	: 29.41 a
SCMV-H	: 21.83 b	: 13.40 b	: 16.17 b
SCMV-I	: 10.96 c	: 7.59 c	: 12.30 c
<u>Pounds of sugar/acre</u>			
Healthy	: 6779 a <u>1/</u>	: 7040 a	: 6375 a
SCMV-A	: 7180 a	: 6435 a	: 6832 a
SCMV-H	: 5709 b	: 3370 b	: 4074 b
SCMV-I	: 2831 c	: 2369 b	: 2903 c

1/ Figures are means of eight replicates; (four replicates each for plant and first stubble crops). Treatment means under any one variety followed by the same letter are not significantly different at the 5% level of probability according to Duncan's Multiple Range Test.

YIELD OF A MAJOR SUGARCANE VARIETY IN LOUISIANA PLANTED
WITH DIFFERENT LEVELS OF MOSAIC IN THE SEED CANE

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Following the discovery, in 1954, that the new H strain of sugarcane mosaic virus affecting NCo 310 would also infect varieties being commercially grown, such as CP 44-101 and CP 52-68, tests were conducted to determine yield losses caused by infection with the new virus strain. All test prior to 1965 were conducted using 100% infected seed cane compared to disease-free seedcane. Results reported by scientists from the USDA Sugarcane Field Station at Houma, Louisiana and the Louisiana Agricultural Experiment Station at Baton Rouge, Louisiana showed that mosaic was reducing yield to a significant degree. However, sugarcane growers on many occasions expressed doubts as to the losses caused by mosaic. As a result, scientists of the two stations began studies (1, 2) to determine how different levels of mosaic in the seed cane affected yield of some commercial varieties.

Yield data collected from two plant cane tests and one stubble test in 1967 and 1968 by Steib and Chilton (1), using L 60-25 as the test variety, showed that a significant loss in yield did not occur until 50% of the stalks used for seed were infected with mosaic. Tippet (2) reported similar findings with L 60-25 and CP 52-68 (combined analyses for 3 crops). The CP 52-68 results were similar to those for L 60-25 for the same years. In one plant cane test in 1967 and a 1st stubble test in 1968, using CP 52-68, Tippet found no significant difference in yield between disease-free and 50% mosaic-infected seed cane. In another plant cane test with CP 52-68 in 1968 and the first stubble of the 1967 test with CP 52-68, he reported a significant difference in yield between healthy and 50% mosaic-infected seed. This indicated that losses due to mosaic may not be consistent from year to year.

Analysis of Results of Plant and 1st Stubble Crops of L 60-25 for 1968, 69 and 70 Planted with Different Levels of Mosaic in the Seed Cane.

Plant and 1st stubble yield data for the 1968, 1969 and 1970 crops of L 60-25 planted with 0, 25, 50 and 100% mosaic-infected seed cane were analyzed statistically.

The results of the combined analysis of the effects of different percentages of mosaic in the seed cane for the 3 plant and 3 1st stubble crops are given in Tables 1-A, B, C and D. Tables 1A and 1C, which include the means of the various treatments for the three years, show that for variety L 60-25, no significant difference was found in tons of cane and pounds of sugar per acre between disease-free and seed cane planted with 25% mosaic. A highly significant loss occurred in tons of cane and pounds of sugar per acre when the seed cane used was 50 and 100% infected with mosaic. A 2.3 ton loss was recorded between 25% mosaic and disease-free seed. It could not be determined whether or not it was a true loss by the analytical methods used. However, it should be noted that the difference between 25% mosaic and 50% was 2.1 tons; it could not be determined whether this was a significant difference between these two levels of mosaic. As previously noted above, however, the loss (4.4 tons per acre) at the 50% level of mosaic was highly significant. Therefore, it is possible that the reduction caused by the 25% level of mosaic could be a true difference.

A year x age (plant cane versus 1st stubble) interaction (Tables 1B and 1D) for tons and sugar per acre, was found to be highly significant for the years included in the test. This interaction was mainly due to the 7.1 tons difference in yield in 1968 between plant and 1st stubble, coupled with the fact that there were no differences in age for 69 or 70. It should be noted that all treatments are analyzed as one when comparing years or ages. In Tables 1B and 1D, the main effect for age (age means) was significant at the 5% level for both tons of cane and pounds of sugar per acre while the main effect for year means was highly significant for both tons of cane and pounds of sugar per acre.

CONCLUSION

Analysis of yield results of 3 plant and 1st stubble tests in 1968, 69 and 70 (Tables 1A, B, C, and D) using 25, 50 and 100% mosaic-infected seed cane as compared to disease-free cane showed that there was no significant loss in yield in tons of cane and pounds of sugar per acre when L 60-25 was planted with 25% mosaic in the seed cane; however, highly significant losses occurred at the 50 and 100% levels of mosaic in the seed cane.

A year x age interaction was found to be highly significant, indicating that plant cane and 1st stubble did not perform the same during 1968, 69 and 1970. L 60-25 did not yield the same each year during the 3 years tested. The yield differences (Tables 1B and 1D), for tons of cane and pounds of sugar per acre for the two ages (plant and stubble) were found to be significant.

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Table 1. Difference in yield in tons of cane per acre and pounds of sugar per acre due to mosaic in the seed cane of L 60-25 for three years in plant cane and 1st stubble for 1968, 1969 and 1970.

<u>Combined Analysis of Plant and 1st Stubble for 1968, 69 and 70</u>					
<u>Means for all years</u>					
<u>A</u>		<u>B</u>	<u>Year x Age **</u>		<u>Year</u>
<u>Treatment</u>	<u>Plant and 1st Stubble</u>	<u>Years</u>	<u>Plant</u>	<u>1st Stubble</u>	<u>Means**</u>
<u>TONS OF CANE PER ACRE</u>					
25% mosaic	32.2	1968	30.5	37.6	34.1
50% mosaic	30.1**	1969	24.9	22.9	23.9
100% mosaic	24.9**	1970	33.6	34.4	34.0
Dis.-free	34.5	Age Means*	29.7	31.6	
Note: There was no significant difference in tons of cane per acre between 25 and 50% mosaic, but the difference was significant between 50 and 100%.					
<u>POUNDS OF SUGAR PER ACRE</u>					
<u>C</u>		<u>D</u>			
25% mosaic	6439	1968	6110	7840	6975
50% mosaic	6125**	1969	4886	5011	4943
100% mosaic	4953**	1970	5888	6376	6132
Dis.-free	6646	Age Means*	5628	6409	

x-P < .05
xx-P < .01

GALLERIA MELLONELLA: AN ALTERNATE LABORATORY HOST FOR MASS REARING
TACHINID PARASITES OF SUGARCANE BORERS, DIATRAEA SPP. 1/

T. E. Summers^{2/}, M. G. Bell^{2/}, and F. D. Bennett^{3/}

ABSTRACT

Experiments with Galleria mellonella (L.), an alternate laboratory host for Tachinid parasites of sugarcane borers, Diatraea spp. indicate that the greater wax moth lends itself to laboratory techniques which make it a candidate for mechanizing the mass production of large numbers of certain of these parasites, particularly the Cuban fly, Lixophaga diatraeae (Townsend.).

INTRODUCTION

With the concern over the effect of pesticide applications on the ecosystems of sugarcane fields and the possibility of their subsequent spread into other ecosystems, there is an increasing need to find suitable alternatives, or supplements, to the use of chemical insecticides for the control of the sugarcane borer Diatraea saccharalis (F.), in those areas where the natural complex of natural enemies does not, under present methods of cultivation, adequately suppress borer populations. Earlier work (Charpentier et al., 1967; Ingram et al., 1951) has indicated that the Tachinid parasites Lixophaga diatraeae (Townsend.), and Paratheresia claripalpis (Wulp), may be capable seasonally of building up populations of appreciable size following their release in Florida, but are not able to survive effectively from year to year due either to the lack of hosts during the winter season, to the effects of the cooler climate, lack of shelter areas, or to some factor associated with the cultivation and harvesting system. As these parasites have provided effective control of D. saccharalis in other areas e.g. St. Kitts, Peru, Barbados, Cuba, they should be considered candidates for use in control programs under Florida and Louisiana conditions, albeit the programs may require either inoculative or inundative annual releases.

During the past several years an annual experimental release program using L. diatraeae imported from Trinidad has been carried out in cooperation with the Talisman Sugar Corporation. These releases have been at low levels (2 to 10 per acre) and have apparently been of value in reducing losses from D. saccharalis. It is desirable that it be determined whether the release of greater numbers of the parasite will result in a high degree of suppression of the borer. Accordingly, there is need for a satisfactory technique to breed these parasites in adequate numbers to provide large releases early in the season when field-collected host larvae, traditionally utilized in the West Indies, are not available. Despite comparatively recent developments wherein techniques for the rearing of D. saccharalis on artificial media have been developed (Hensely et al., 1968; Walker et al., 1966), there is need for an alternate laboratory host that can be reared more rapidly, more easily, and more economically.

Following early investigations in Taiwan where L. diatraeae was successfully reared on Brachmia modicella Christoph (Chen and Hung, 1960), a series of other readily available potential hosts were tested in Trinidad. Bennett and Simmonds (1966) obtained very promising results with L. diatraeae on the greater wax moth, Galleria mellonella (L.), and the Cassia pod borer, Trachylepidia fructicassiiella Rag., and encouraging results with P. claripalpis on G. mellonella. Subsequently in Trinidad, because of its ready availability, T. fructicassiiella has been utilized in a breeding program wherein more than 50,000 L. diatraeae have been produced. According to L. C. Scaramuzza (pers. communication, July 10, 1968), G. mellonella has been utilized in a routine breeding program for this parasite in Cuba.

In view of the need for large numbers of L. diatraeae to undertake pilot trials for control by the release of a high level of parasites per acre, and also for a study concerning integrated control of D. saccharalis in Florida, experiments with G. mellonella have recently been carried out at Canal Point, Florida. Utilizing primarily stocks of L. diatraeae, supplied from Trinidad. The results of the inoculations with L. diatraeae onto G. mellonella at Canal Point, are reported herein.

Methods of rearing Galleria Mellonella.

The greater wax moth has been utilized as a factitious host for numerous other entomophagous insects, nematodes and viruses because of the ease in mass culturing it in the laboratory. Numerous

1/ This research was supported in part by a grant from Mr. Wm. D. Pawley, President of Talisman Sugar Corporation to the Entomology Department, University of Florida, Gainesville, Florida.

2/ Entomology Research Division, Agricultural Research Service, U.S. Dept. of Ag., Canal Point, Fl.

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specially devised diets have been reported, including (Peterson, 1959; Dutky et al., 1962) for rearing the wax moths. However, the preliminary work in Trinidad and in Florida was done by mass rearing on honey comb, a straight-forward operation requiring only a series of gallon jars, paper toweling and a regular supply of honey comb.

At Canal Point certain disadvantages with honey comb were experienced. These were: (a) the wax moth larvae had to be removed from the residual comb by hand, a time consuming and hence expensive operation; (b) the colony was more vulnerable to bacterial disease; and (c) on one occasion a braconid parasite of the wax moth larvae was introduced with the honey comb and almost wiped out the colony.

Due to these problems subsequent rearing was accomplished either using Dutky's (1962) diet or that of Haydak (1936).

The adult wax moths were allowed to deposit eggs on folded wax paper which were transferred to the rearing medium, or the bottom and lower third of the gallon rearing jars coated with the honey-glycerol mixture and dusted with Pablum and the adults allowed to oviposit directly on the walls of the rearing jars. Additional food being added later.

Methods of inoculating and holding host larvae.

Apart from a few exceptions the techniques for breeding L. diatraea and P. claripalpis on G. mellonella at the Trinidad laboratory were similar to those utilized with D. saccharalis. The gravid parasite female is dissected in a drop of tap water or isotonic salt solution and the maggots placed by means of a small paint brush onto the host larva. Following inoculation, the larvae may be placed with food in small plastic containers or glass vials until the fully developed parasite maggots emerge and pupate. Because of the lower water content of honey comb compared with sugarcane, mortality in the prepupal and early pupal stages may be higher when the parasites are reared on wax moth unless damp cotton, or a piece of sugarcane or other plant material is added to increase the humidity in the rearing container.

At the Canal Point laboratory in addition to placing one to five parasite maggots per G. mellonella larva by paint brush two other techniques were tried. In the first, 50 larvae were placed in a Petri dish and a water-maggot suspension was swabbed quickly over the entire mass of host larvae. The other technique was to simply place three drops of a water-maggot inoculum, containing 250-300 (i.e., 5-6 maggots per host larva), in a clean Petri dish, place 50 host larvae in the dish and let them squirm through the inoculum and thus inoculate themselves. Food may be added to the Petri dish or the larvae may be left in the dish without food until the parasite maggots emerge and form puparia. The wax moth larvae produce very little webbing and thus the recovery of the parasite pupae is easy and rapid.

Results of inoculations in Trinidad and Florida.

While the results of inoculations in Trinidad have already been published (Pschorn-Walcher and Bennett, 1970), they are again included here for comparison with those obtained in Florida (Table 1).

Table 1. Host suitability tests with Galleria mellonella undertaken in Trinidad (adapted from Pschorn-Walcher and Bennett, 1970).

Parasite species	No. of tests	Hosts inoculated	Mag. per hosts	Hosts par. (%) mean	Parasite survival (%) mean
Lixophaga	4	991	2	45.5	28.9
<u>Paratheresia</u> Trinidadian	3	300	2	26.4	13.3

The Trinidad experiments were of a preliminary nature and were carried out before it was realized that moistening the larvae improved the level of success.

The Canal Point experiments were conducted with emphasis on rearing L. diatraea, but the results may well apply to other Tachinid parasites. A major effort was directed toward modifying the method used in Trinidad to make the breeding of the parasites in large numbers as economical and as rapid as possible. The data from the Canal Point tests are given in Table 2. It is seen that the parasite per host larva ratio was practically as good using the mass swabbing and self-inoculating technique as was the best return from hand inoculation of individual larva.

Table 2. Lixophaga diatraeae puparia per Galleria larva individually hand inoculated and inoculated in mass (groups of 50 host larvae).

No. Tests	No. Host inoculated	Maggots per host	No. Parasite Puparia recovered	
			Total	Per Host
10	500	1	290	.58
10	450	2	535	1.20
3	333	3	416	1.25
10	405	4	745	1.84
10	500	5	700	1.40
5	250	swabbed in mass	435	1.74
5	250	mass inoculum placed in dish	450	1.80

DISCUSSION

In Trinidad where Trachylepidia fructicassiella has been utilized as a laboratory host for rearing L. diatraeae for several generations, there has been no evidence of a decline in fecundity or longevity nor increased mortality in the immature stages. However, according to L. C. Scaramuzza (pers. comm., 1968) the walls of the puparia become very thin and fragile when L. diatraeae is reared for successive generations on G. mellonella, factors contributing to higher mortality due in part to desiccation and in part to mechanical injury during removal of the puparia from the rearing containers. These difficulties have not been encountered during recent experiments at Canal Point. Parasites reared on G. mellonella and subsequently inoculated onto D. saccharalis readily accepted the diatraea host. It is apparent that G. mellonella would lend itself to a mechanized scheme of mass production of L. diatraeae. Particularly encouraging are the facts that: (a) the G. mellonella larvae may be separated from the rearing media by a sieving process, (b) the inoculation of the larvae by mass techniques may be accomplished without resort to individually placing the maggots on individual host larvae (as is done with D. saccharalis), and (c) it is not necessary to feed the larvae between inoculation and pupation of the parasite. Also, when the host larvae are not fed after inoculation the parasite puparia are left free from most entangling material thus facilitating their collection prior to the emergence of the adult parasites.

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FULL CONTINUOUS C CRYSTALLIZER STATION

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ABSTRACT

A description of the continuous system installation made at Atlantic Sugar Association in 1967.

The existing blanchard crystallizers were connected with no strike receiver built under the vacuum pans.

A pump was installed between the no. 2 and 3 crystallizers and automatic level control was provided to keep the pump working continuously.

No operational difficulties have been associated with the system except the breakdown of a crystallizer which would make the liquidation necessary in order to repair it, shutting down the continuous operation.

Automatic control equipment is provided at the centrifugal station and results have been very satisfactory.

The 100% continuous operation only requires supervisory attention and no labor is involved in the entire station.

INTRODUCTION

The C crystallizer station of Atlantic Sugar Association was modified during 1967. The batch system was changed for the continuous operation which has been introduced during the last decade in many sugar mills throughout the world.

Since its beginning Atlantic has had six low grade "U" type crystallizers with Dyer Blanchard cooling system and a capacity of 1,400 cu. ft. each, which discharge manually to a mixer of 350 cu. ft. capacity with a Fischer & Porter automatic heating control.

The C strikes were dropped from the pans to a trough located on top and running all along the crystallizers.

A battery of four Allis Chalmers continuous centrifugals was operating at the C massecuite station. The sugar magma was controlled manually and pumped to a seeder which overflowed in a melter and ran by gravity into the juice line from the clarifiers to the evaporator supply tank.

Considering a grinding rate of 5,000 tons per day with a 30 hour retention time in our C massecuite, it would be necessary to increase the existing number of crystallizers to eight and also to extend the building for their location.

Because of the cost of an expansion in our C crystallizer station and knowing of the advantages obtained by other plants with the change, we decided to go to the continuous operation since all the batch system installations could stay as before and ready to be used if necessary.

PLANT INSTALLATION

The crystallizers (see Figure No. 1) were connected alternately by troughs 1.5 ft. wide by 2 ft. deep, the height increasing up to 2.5 ft. in the last unit. Each trough is provided with a gate so that in case of any problem you are able to separate the crystallizers.

A baffle plate was fitted at the center of the crystallizers reaching from the top of the shell down to the stirrer shaft, in order to prevent the massecuite from travelling along the top of the unit without coming in contact with all cooling elements. No strike receiver was built under the vacuum pans, and the C massecuite is dropped into the first two units that were connected by a 20 in. diameter pipe, taking no more than 3 to 4 minutes for discharging operation.

We added to the system an 11 in. pump with a speed of 48 R.P.M. for massecuite of 95 brix. It is fed by a 12 in. pipe located at the bottom of no. 2 crystallizer, and discharged through a 10 in. line into a box 1 ft. wide by 4.5 ft. long by 1 ft. high. This box (see Figure No. 2) is divided between the no. 2 & 3 crystallizer by a gate controlled by a Honeywell valve which receives the level signal

from the no. 3 unit through a Taylor transmitter that acts over a pressure switch, opening a solenoid valve and keeping the pump working continuously.

The discharge valve on the last unit (see Figure No. 3) is controlled automatically by a Copes Vulcan actuator which receives the level signal from a Taylor transmitter located on the C sugar mixer and is regulated by a Fischer & Porter control indicator.

This level control of the C sugar at the mixer is of great importance for the feeding and capacity of the continuous centrifugal.

To complete a 100% continuous operation in our C crystallizer station we have four Allis Chalmers continuous centrifugals, model 2750, and automatic control of the density in our C sugar magma.

The automatic control is made through a Taylor transducer that checks the ampere's variations of the motor that moves the conveyor, changing the electrical signal into pneumatic and sending it to a Honeywell valve through a recorder controller.

A 3/4 in. pipe is used for the addition of clarified juice or syrup to the C sugar and in front of each centrifugal this line is reduced to 1/2 in. with a gate installed at the end.

The excess of C sugar at the magma seeder is controlled automatically with a level control system similar to the one in the no. 2 and 3 crystallizers.

When the level of the seeder reaches a height equal to one charge of magma in the pan, the control valve closes the seeder inlet and the excess of magma runs directly into a 6 in. pipe that is connected to the juice line from the clarifiers to the evaporator supply tank.

RESULTS

The cooling system is used only at the last three crystallizers and we have from the C strike pan to the no. 6 crystallizer a temperature differential of 145 - 135 to 100°F.

The brix average of the C massecuites during the last four crops has run from 96.00 to 97.00 without having any difficulties with the massecuite flow.

With the continuous system, used in our last four crops, our average final molasses apparent purity has been 34.71 while during the time we used the batch system the average apparent purity was 35.83.

Our grinding rate has been increased from an average of 171.00 tons to 185.00 tons per hour.

Lubrication with hot final molasses in our Dyer Blanchard crystallizers has not been necessary, nevertheless we have used during the last couple of years a nonionic surfactant called Mazu 400 additive, obtaining an excellent result especially in the fluidity of the C massecuites when maximum cooling has been reached.

No operational difficulties have been associated with the system except the breakdown of a crystallizer which would make the liquidation necessary in order to repair it, shutting down the continuous operation.

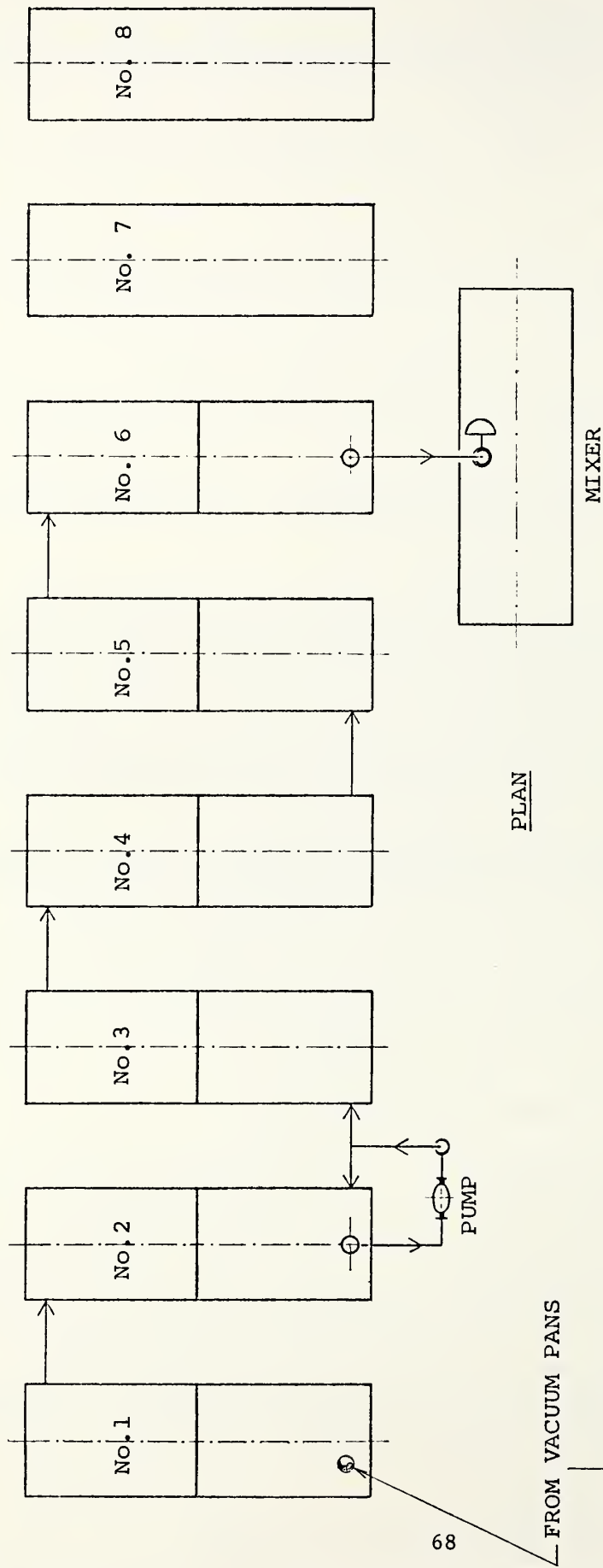
ADVANTAGES OF THE FULL CONTINUOUS SYSTEM

1. Utilizes the cooling surface area to the maximum, giving more capacity in your crystallizer station.
2. Better control with low grade centrifugals.
3. Increase the capacity of the centrifugal station because the massecuites temperature is more uniform.
4. No labor is involved in the entire station.
5. The addition of chemicals to the massecuites is better regulated.
6. Time used for C strikes dropping is minimum, giving at the same time more flexibility.
7. Screens broken at the centrifugals are reduced to a minimum.
8. The heating and cooling of massecuites are better controlled.
9. Strikes can be dropped with a higher brix.
10. The attention required of the entire system is completely supervisory.

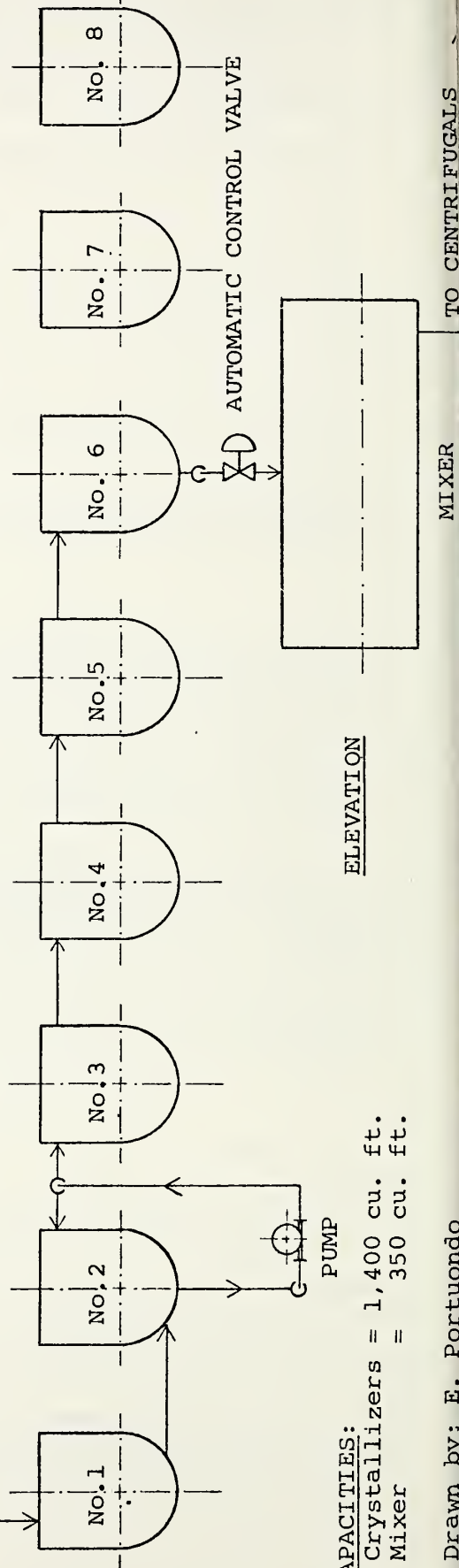
Figure No. 1

CONTINUOUS LOW GRADE CRYSTALLIZERS STATION

A & B
SUGAR CRYSTALLIZERS



PLAN

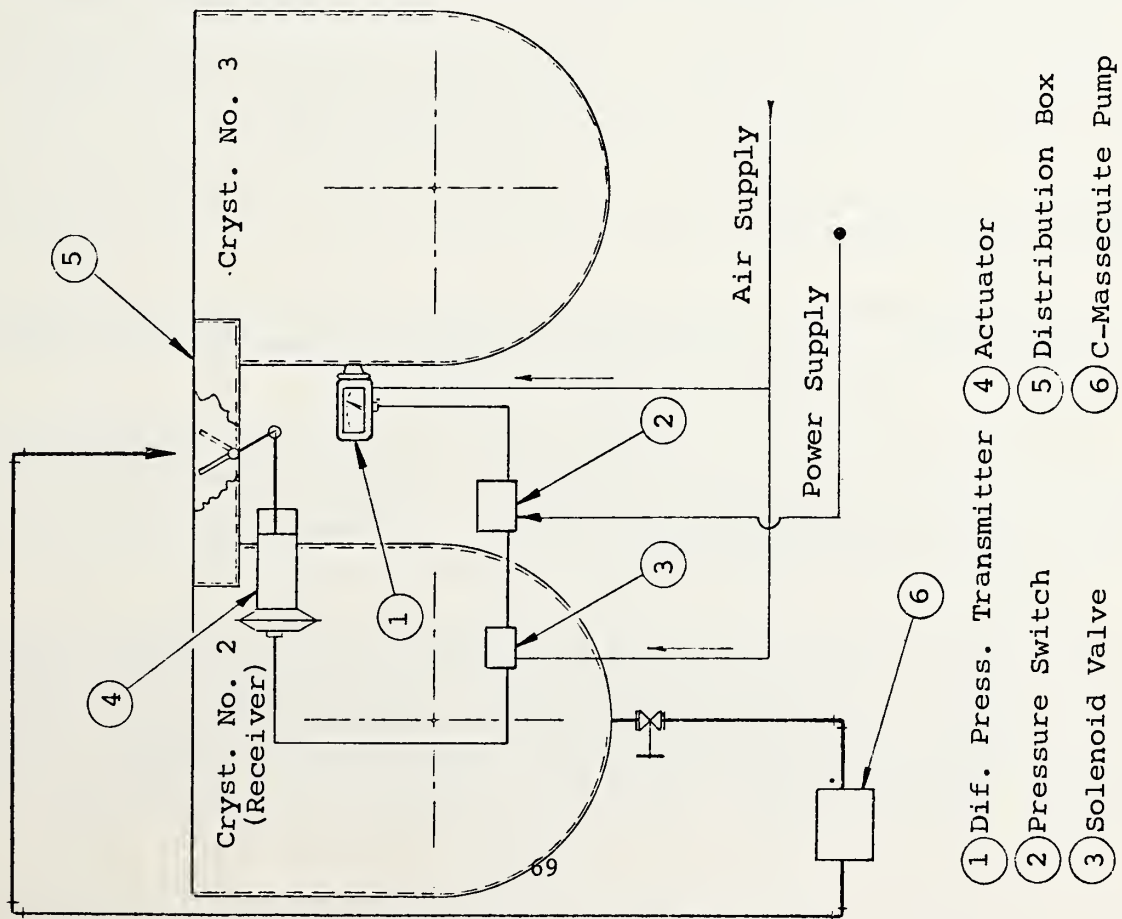


ELEVATION

CAPACITIES:
Crystallizers = 1,400 cu. ft.
Mixer = 350 cu. ft.

Drawn by: E. Portuondo

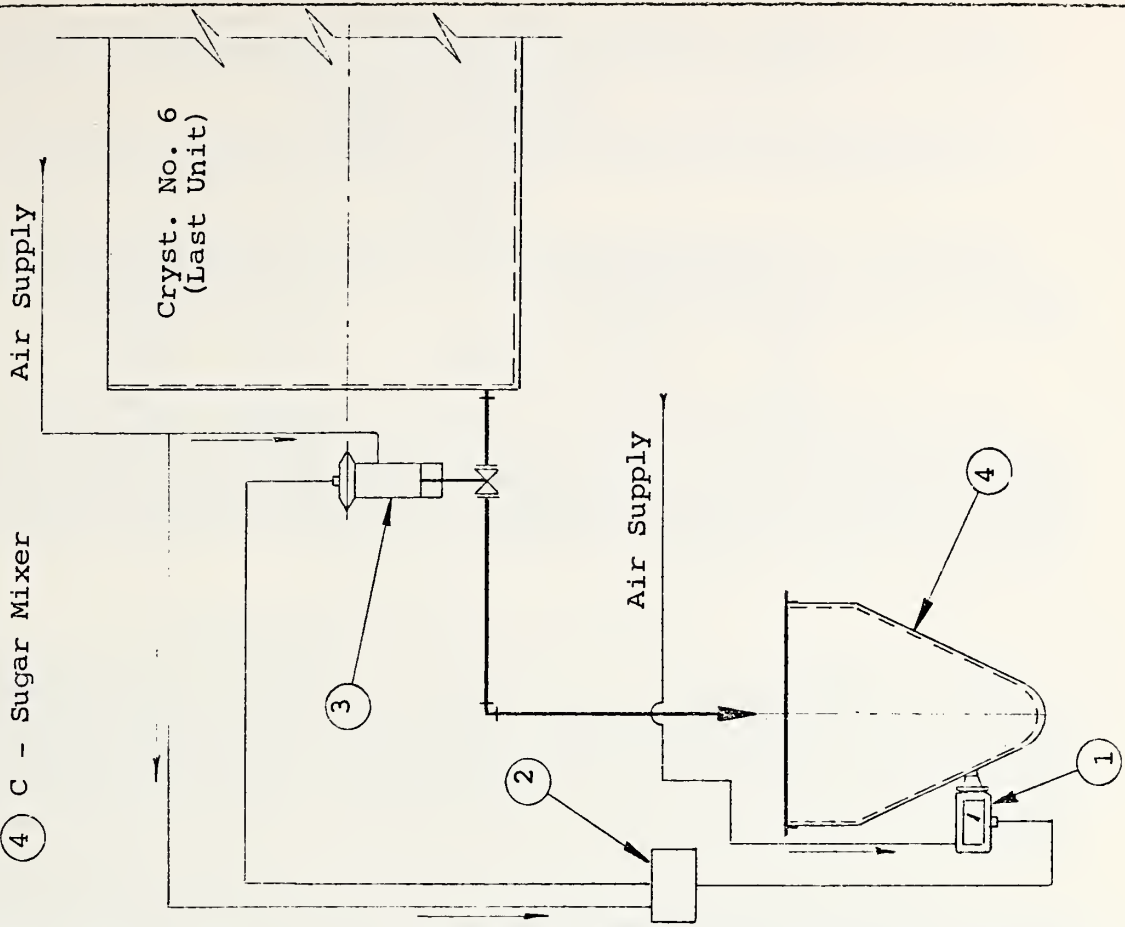
Figure No. 2



Drawn by: E. Portuondo

Figure No. 3

- 1 Differential Pressure Transmitter
- 2 Control Indicator
- 3 Actuator
- 4 C - Sugar Mixer



PRODUCTION OF HIGH QUALITY REFINED SUGAR

Aramis Alvarez
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ABSTRACT

Description of a sugar boiling process to produce not only high polarization raw sugar but to improve other refining qualities, and at the same time maintain the exhaustion of final molasses. Includes a sketch of the basic changes from other processes and some comparative data.

INTRODUCTION

For the last twenty years we have seen a remarkable improvement in the quality of raw sugar. Beginning with the works of E. C. Gillet on the technology of low-grade boiling, followed by the development of the new two and three boiling systems with their different variations, the appearance of the completely automatic and continuous centrifugals, the use of water-soluble polymers to help the clarification and finally, the automatization of many of the phases of the process, it has been possible for the industry to improve the quality of the raw sugar produced.

PRODUCTION OF HIGH QUALITY REFINED SUGAR

When it is needed to refine the total production of raw sugar or it is necessary to deliver it to a refinery without affination station, we must make use of all the improvements of these last twenty years if we are to be successful, and that is what we tried to achieve at Central Matilde, Venezuela, using at the same time an old sugar boiling system. We say old sugar boiling system because it consists essentially of using the "B" sugar as footing for the "A" sugar strikes. This had been tried before in different factories, but now, using the seeding of low grade molasses and continuous centrifugals for "B" and "C" sugars, this process has proved to be a very good one during five years of operation.

All of the raw sugar produced through this system comes out of "A" strikes. The "A" strikes are made using magma of "B" sugar and feeding the pan with syrup to the end. This is a great advantage for refining purposes because no matter what the purity of an "A" strike turns out to be, once we use any molasses in making it, we can notice the difference judging from the change in color.

The purity of this "A" strike will vary with the syrup, but it makes little difference how high it may go as we can always get from the "B" strikes molasses purities low enough to fix the "C" strikes at any desired point. Grain size of this "A" sugar may be controlled by successive cuttings, but normally, coming from such a pure strike they do not need to be too large.

The "B" strikes are made using the "C" sugar magma ("C" sugar and "A" molasses) as footing, and feeding to fill the pan with "A" molasses. No cuts are made to increase the grain size in these strikes because the main purpose of this is to improve the purity of the "A" strike footings and to obtain low purity molasses.

The purities will vary normally from 66% to 69% and may be purged in any type of centrifugal without washing the sugar. Here we took advantage of the continuous centrifugals that give larger capacity with this type of sugar, are comparatively low cost equipment and require less labor to operate. These centrifugals may be used to repurge the surplus of "C" sugar magma.

The "B" molasses purity will vary from 45% to 50%, and here we have the advantage of obtaining a low purity molasses that allows us to go as low as we may consider necessary on the "C" strike purities without interfering with the quality of commercial sugar. The molasses from repurging the "C" sugar magma will be mixed with the "B" molasses. When the "C" sugar magma is made with "C" sugar and "A" molasses, the purity of the repurged molasses will be 4 to 5 points below the "A" molasses purity, and the volume being comparatively small, will not raise the purity of "B" molasses more than 1 or 2 points. The repurged sugar will be dissolved and mixed together with the syrup.

The "C" strikes will be made by seeding "A" molasses in the already established processing way of mixing "A" molasses and syrup to any desired purity. Either method has a wide margin, having low purities "B" molasses, to adjust the purity of the strike. Here we found another point of preference for continuous centrifugals. These centrifugals give good "C" sugar with almost any kind of massecuite. Our own experience is that when we have only continuous centrifugals at the "C" sugar station, we obtain lower purities and higher densities on the "C" strikes and a better exhaustion of the final molasses. As with any other sugar boiling process, this one will need to be adapted to the different problems of individual sugar mills. Where high purities prevail you will need separation of the

washing syrup at the "A" centrifugals. When the purities drop too low, the number of "B" strikes will be reduced to a minimum or perhaps disappear. Then you will need the "B" centrifugals to help your "C" sugar centrifugals.

Following you will find, as interesting data, the percentages of different massecuites produced at Central Matilde using this process and refining 90% of the raw sugar produced and also Atlantic Sugar Mill using the new three boiling system (as described in the 9th edit. of Spencer-Meade Handbook), and producing raw sugar of 98.7% pol.

<u>ATLANTIC SUGAR</u>		<u>CENTRAL MATILDE</u>	
A Strikes	43.4%	A Strikes	<u>67.1%</u>
B Strikes	33.8%	Comm. Sugar Strikes	<u>67.1%</u>
Comm. Sugar Strikes	<u>77.2%</u>	B Strikes	14.8%
C Strikes	22.8%	C Strikes	<u>18.1%</u>
	100.0%		100.0%

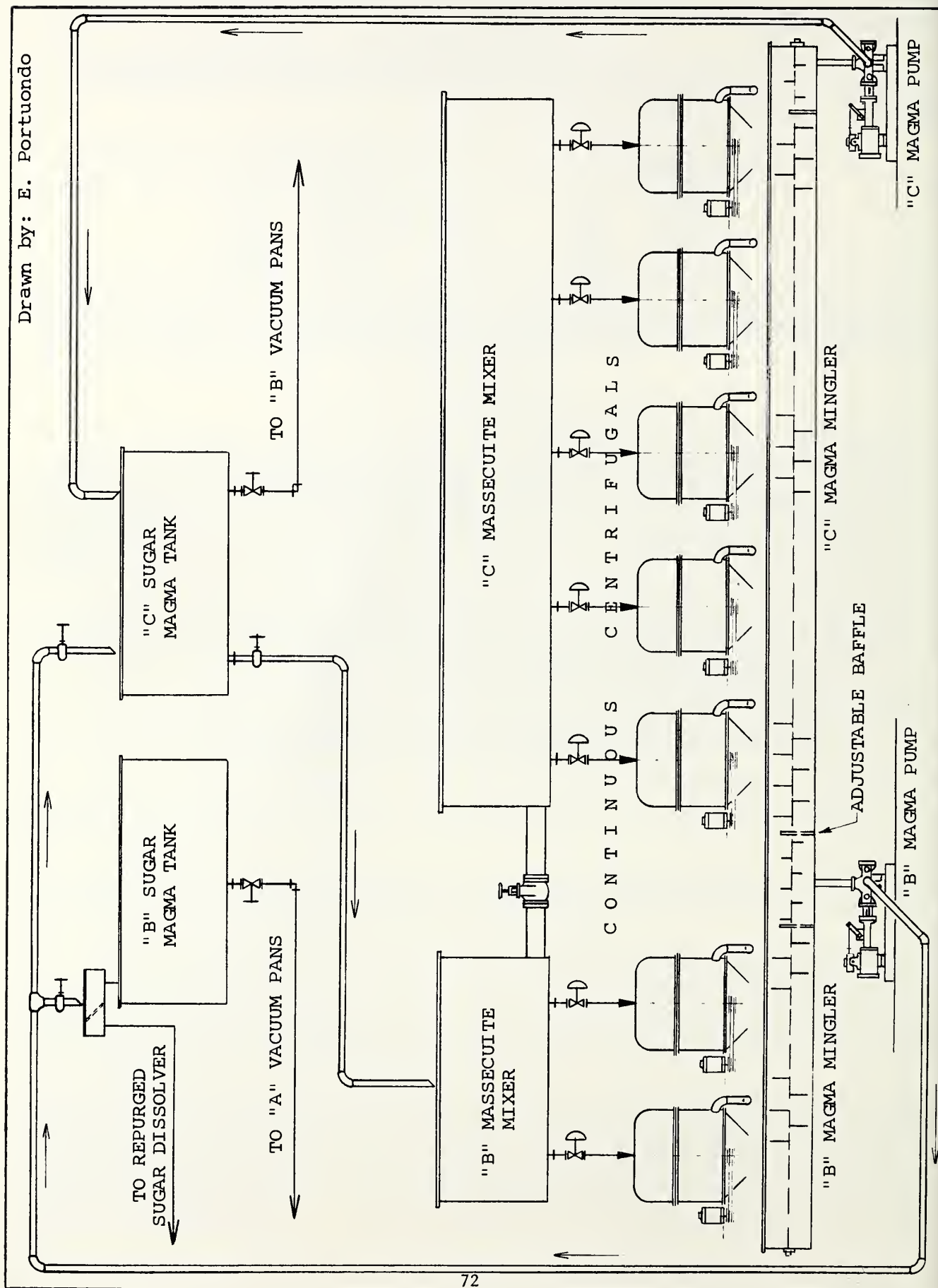
Schematic diagram #1 shows the installations and flow of materials at the "B" and "C" centrifugal stations where the changes from conventional processes take place.

CONCLUSIONS:

The advantages found from the process are:

1. All the commercial sugar comes from high purity strikes made without molasses.
2. The remaining film of final molasses that comes to process with the "C" magma is eliminated from the "A" strikes.
3. This type of strike increases the capacity at the "A" centrifugal station.
4. The grain size of this high quality refined raw sugar does not need to be too large.
5. The "B" strikes are made very quickly and easily because they have a lot of grains.
6. You do not need any calculations for purities on "A" and "B" strikes. This, together with the two previous paragraphs, relieves the sugar boiler of a great part of his always needed experience.
7. The purities of the "C" strike may be adjusted at any point considered optimum for final molasses exhaustion, without damaging the quality of the commercial sugar.

Drawn by: E. Portuondo



COLOR IN RAW SUGAR CANE INDUSTRY;
CAUSES AND CONSEQUENCES

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ABSTRACT

A study of causes that build up color in raw sugar and recommendation of methods to avoid it. Description of experiment made storing raw sugar at different temperatures and graphic showing the results.

INTRODUCTION

Color build up in raw sugar is a source of losses in sucrose and, of course, in money; especially in Florida where a large amount of raw sugar has to be stored for long periods of time. Some of the mills store up to 75% of their production.

These losses are mainly due to the fact that an increase in color brings a drop in pH and polarization of the sugar. In September of 1966 the American Sugar Company started to apply contract No. 10 to the purchase of raw sugar; which contract, as it is well known, bears different penalties in the price of sugar. One of the most important of these penalties is color. The objective of contract No. 10 is for the refineries to have raw sugar of good quality for refining.

In order to produce raw sugar of low color, the first step must be to have a good juice clarification with a pH of about 6.8 for the clarified juice. The use of lime, phosphoric acid and the aid of one of the new polymers as coagulant is the regular procedure for this purpose. The hot juice entering the clarifiers must have a temperature of no less than 212°F.

From this point on the temperatures in the rest of the process has to be well controlled, since the heat is the main source of color building in the raw sugar house. Excessive temperatures in the evaporators must be avoided and also in the pans. No strike must be boiled under high temperature. The use of sodium hydrosulphite on the low massecuite strike helps to keep the color low and at the same time cuts the viscosity of the massecuite.

All crystallizers in the sugar house should be provided with a cooling system to control the temperature of the massecuite before drying in a way that the sugar leaving the centrifugals be as cool as possible. The sugar must never reach the warehouse pile at temperatures beyond 90°F. When the sugar is stored at temperatures of 100°F or more the building up of color is fast, increasing with each degree of temperature increase.

The following experiment was made with a sample of sugar from Clewiston Sugar House in 1969:

A sample was taken immediately after leaving the centrifugals with a temperature of 122°F.; a polarization of 98.24; moisture of 33%; color index number 34. The sample was then divided into four equal portions and kept at different temperatures in the laboratory for a period of 16 days, as follows:

Sample #1 was kept at temperature of 24° C - (75° F.)
Sample #2 was kept at temperature of 37.5° C - (99.5° F.)
Sample #3 was kept at temperature of 43.5° C - (110.3° F.)
Sample #4 was kept at temperature of 50° C - (122° F.)

During this 16 day trial five color tests were made at different number of days of incubation, with the following results:

	<u>SAMPLE #1</u>	<u>SAMPLE #2</u>	<u>SAMPLE #3</u>	<u>SAMPLE #4</u>
TEMPERATURE	24° C (75° F)	37.5° C (99.5° F)	43.5° C (110.3° F)	50° C (122° F)
Color after one day	34	34	40	40
Color after two days	35	36	40	41
Color after four days	35	37	41	43
Color after eight days	36	38	45	56
Color after sixteen days	36	41	57	96

Sample No. 1 kept at 75° F. shows an increase in color from 34 to 36 or two color units in 16 days which is an increase in color of 5.88%.

Sample No. 2 kept at 99.5° F. shows an increase in color from 34 to 41 or seven color units in 16 days, which is an increase in color of 20.59%.

Sample No. 3 kept at 110.3° F. shows an increase in color from 34 to 57 or 23 color units in 16 days, which is an increase in color of 67.65%.

Sample No. 4 kept at 122° F. shows an increase from 34 to 96 or 62 color units in 16 days, which is an increase in color of 182.35%.

There is no question that the temperature at which the raw sugar is stored is the most important factor to avoid fast rise in color and, of course, drop in pH and polarization. Polarization is very important in sugar warehousing. Raw sugar with high polarization, for instance 98.60 or better, will always keep its qualities better than raw sugar with a polarization of 98.00 or less.

As the temperature of the raw sugar leaving the centrifugals is in the neighborhood of 130° F. in most of the sugar houses, a good solution to this problem could be a sugar cooler with enough capacity to handle the total production of the factory.

The attached graph gives a better idea of the influence of temperature in a raw sugar house.

The method for the color determination in this experiment is also attached.

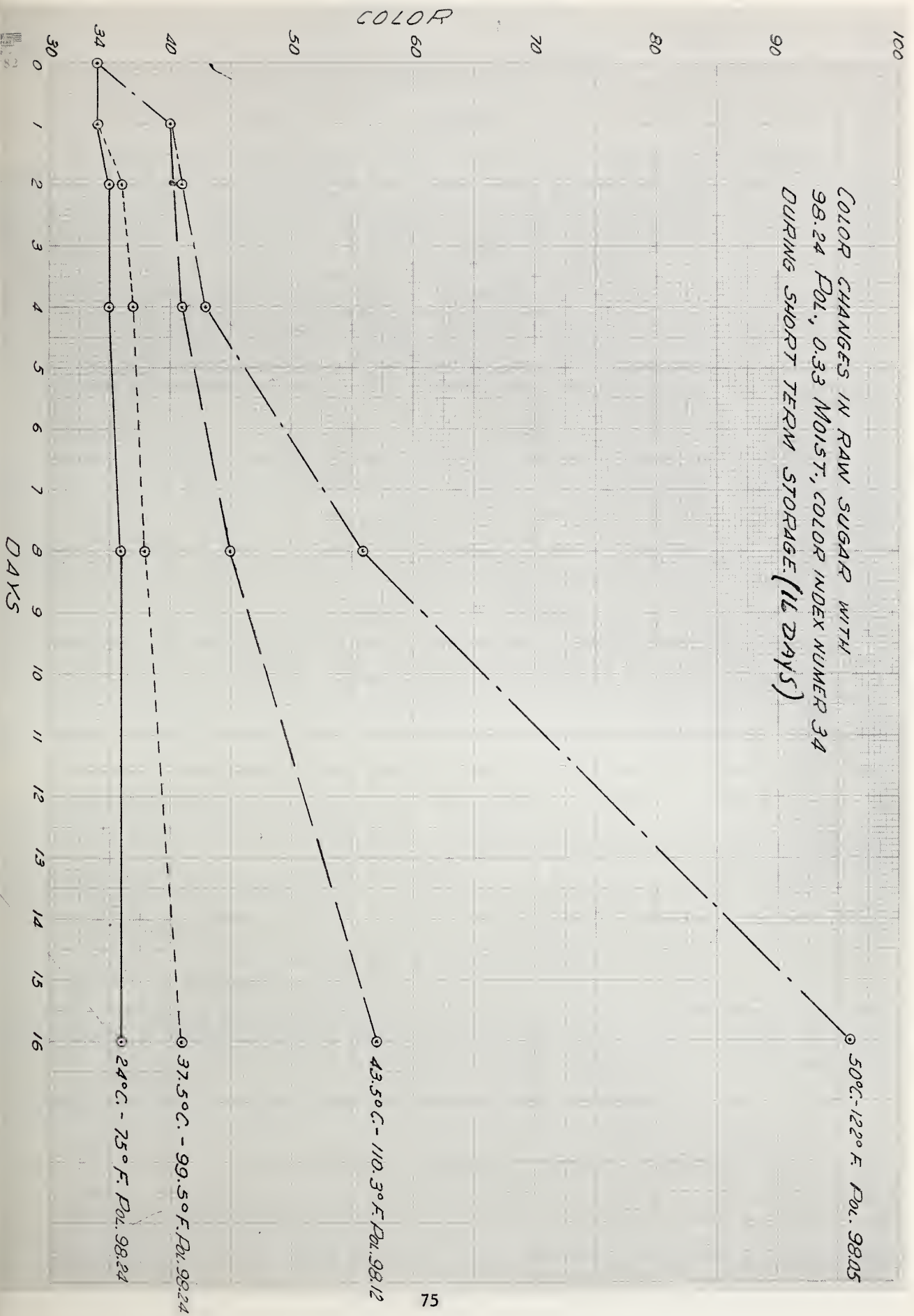
PROCEDURE FOR DETERMINATION OF RAW SUGAR COLOR INDEXES

Dissolve raw sugar in an equal weight of water, giving approximately 50° brix. If the raw sugar is extremely dark in color, it will be necessary to adjust the brix lower in order to obtain a reading on the spectrophotometer. Filter the raw sugar solution through an asbestos filter in a gooch crucible, and record the filtrate brix. Transfer the filtrate into a test tube of 12 mm diameter. Read the percent transmittance as compared to water in a matched test tube in a B. & L. Spectronic 20 Spectrophotometer using 560 millimicrons wave length and blue sensitive photo tube. Calculate the color index according to the following formula:

$$C. I. = \frac{-\log T_s}{bc} \times 100$$

Where: C. I. = Color index of the raw sugar
Ts = Transmittancy
b = Cell length, cm
c = Concentration of total solids, gms./ml

COLOR CHANGES IN RAW SUGAR WITH
98.24 POL., 0.33 MOIST., COLOR INDEX NUMBER 34
DURING SHORT TERM STORAGE (16 DAYS)



CANE POL VS. CANE SUCROSE

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ABSTRACT

According to ISSCT definition, Pol is used in calculation as if it were a real substance. For simplicity and convenience, Pol, instead of true sucrose, is being used in chemical and factory controls. But Pol is Pol, and should not be taken as true sucrose. The polarization of an impure sugar solution (e.g. cane juice) could be affected by other optically and non-optically active substances. So there is no conversion factor between Pol and sucrose. Due to decomposition of levulose or enzymatic effect of dextrose, the D/L ratio varies from place to place, and from time to time. It could also vary during manufacturing process or during the storage of sugar products. The evaluation of sugar yield depends on the actual sugar content in cane. Since Pol does not always represent the actual sugar content, the evaluation by Pol could sometime be very misleading. If cane is paid by sugar content, and the sugar content is based on Pol which may have wide discrepancy to actual sucrose, then either the cane producers or cane processors might suffer unjustifiable losses, especially under abnormal conditions.

According to the official definition of the ISSCT, Pol is used in calculation as if it were a real substance. It is therefore understood that although Pol is being used in operation and chemical controls, Pol is Pol, and is strictly NOT sucrose.

In chemical control of a sugar factory, for simplicity and convenience, the material balance and recovery efficiency are based on Pol figures. Also in operation control, the purity figures are all apparent purities, using Pol instead of real sucrose. But Pol remains Pol, and should/could not be taken as actual sucrose. This could be easily explained by the difference of Pol and Sucrose in a blackstrap molasses.

The practice of using "sucrose" to mean Pol, such as "sucrose extraction", "sucrose loss" and "purchase of cane on sucrose basis", where Pol is meant, is so ingrained ¹⁾ that only "actual sucrose" or "Clerget sucrose" could actually mean real sucrose.

RATIO OF POL TO SUCROSE

An impure sugar solution generally contains sucrose (dextrorotary, +), dextrose (dextrorotary,+) and levulose (levuratory, -). So the polarization of this solution is in fact the resultant of the polarization of all the three sugars. Besides from dextrose and levulose, there are also other optically active non-sugars, such as dextran and gums that will influence the polarization ⁵⁾. Moreover, some mineral salts also affect the rotation of sucrose²⁾. Honig⁴⁾ had also proved that those non-sugars influencing the rotation of sucrose are (a) those having their own rotation, e.g. dextrose, levulose, some amino acids, etc., (b) those inactive substances, e.g. salts of sodium, potassium and alkaline earths. Therefore the °S of impure sugar solution is not always identical with the exact content of sucrose.

As we know that the relative proportions of other optically active non-sugars, mainly dextrose and levulose, vary from place to place, resulting in the variation of the ratio of Pol to Sucrose. Generally, sucrose figure is higher than Pol. But it is not uncommon that it could also be lower. These were known and reported by Zerban and his colleagues in 1942.³⁾

If there is a definite ratio between Pol and Sucrose, even though Pol $\neq$ Sucrose, we could convert one into another by using a conversion factor. But there is none.

RATIO OF DEXTROSE TO LEVULOSE

Dextrose and levulose are two main optically active non-sugars in sugarcane juice. Normally these two monosaccharides are in 1 : 1 ratio. When sugar is hydrolyzed, the products of inversion are also in 1 : 1 molecular ratio. But this ratio may not stay constant. It may vary from place to place and from time to time, and even during the manufacturing process of sugar. Data of some raw sugars from different producing countries show wide ranges of variation. (Table 1.)

Gardiner and Muller ⁷⁾ had found some raw sugars, stored under unsuitable conditions, changed D/L ratio from 1.0 to 8.0, with levulose degradation products and large amounts of ketose and allulose.

The changing of D/L ratio could be due to increase of dextrose of decomposition of levulose. It is also found that some enzyme could convert dextrose into levulose. In that case, the D/L ratio decreases.

SUGAR YIELD VS. CANE POL

The yield of sugar depends on the sugar content in the cane. The sugar content in the cane could be determined either by

- a) Direct method -- analyzing sugar in cane, using direct samples; or
- b) Indirect method -- analyzing sugar in mixed juice and sugar in bagasse. Then the sum of these two divided by weight of cane.

In either method, sugar content has been expressed generally by Pol and not Sucrose. As it is already proved that (1) there is no definite ratio between Pol and actual sucrose, (2) there is no constant ratio between dextrose and levulose; and also (3) some other optically active non-sugars as well as some non-optically active non-sugars could affect Polarization, therefore the using of Pol in the predicting and computerizing actual yield could only be arbitrary, and under abnormal conditions, could be misleading.

CANE POL VS. CANE SUCROSE

Looking up those publications in The Sugar Journal (since 1947), and Sugar Bulletin (since 1937), the evaluation on cane varieties were all based on Pol, with only limited information on actual sucrose, as reference. Very commonly where "sucrose" was used, it actually meant "Pol".

From previous studies by Fort and Smith ⁸⁾, the sugar content in different cane varieties as expressed by Pol was in every case, not identical with actual sucrose (Table 2); and without exception, sucrose was always higher than Pol.

During the first part of the 1970 grinding campaign in Louisiana, the juice purity was high and the Pol in juice was also high. According to Government official method of evaluation -- basing on Pol and Purity of Normal Juice, the expected Yield was not in line with the actual Yield and seemed to be way off. (Fig. 1). During the first 10 days of the crop, the two curves were close together. Then during the next 20 days, both curves were well apart. A heavy frost occurred on the 36-37th day, which confused a normal evaluation.

During the first few days of the 1970 crop, it was noticed that the high Pol in juice did not reflect high yield of sugar, and so some doubt was placed on the polarization of juice. First, all Pol readings and samples were thoroughly checked and no fault was found. Then the question was raised as to how close could the Pol relate to actual sugar content, which led to our determination of Pol vs. Clerget Sucrose (Table 3), using the new cane variety L-6025 to compare with the old cane variety CP-5268.

Although it was known that there could be different non-sugars which could affect the Pol, yet the D/L ratio could be a good indication of abnormality. We had the cooperation of the Refined Syrups & Sugars Inc., Yonker, New York to run tests on our juice samples, using their newly developed Gas-Liquid Chromatography techniques, for the quantitative determination of Sucrose, Dextrose and Levulose. (Table 4)

From the results obtained, it could be seen that not only the D/L ratio is different from one variety to another; but also the reducing substance other than dextrose and levulose, (expressed as Inverts - dextrose - levulose), has higher percentage in one variety than other.

It is evident that the variety L-6025 has less sucrose than Pol, while the variety CP-5268 has more sucrose than Pol. According to the specific rotation $[\alpha]_D^{20}$ of dextrose and levulose, the difference in D/L does not give such a difference between Pol and sucrose. It is therefore obvious that other non-sugars are also complicating the polarization.

Before more tests could be carried out, there was a heavy frost on the 36/37th Crop days, which made some physiological change inside the cane. In order to see how much the frost could change the D/L and the polarization of juice, again some samples were sent to the Refined Syrups & Sugars for sucrose, dextrose and levulose determinations. (Table 5)

It could be seen that the frost had caused the cane to change the content of those sugars and also to increase rapidly in the reducing substances other than dextrose and levulose. It is also noted that under normal conditions, CP-5268 has higher sucrose than Pol, but after the frost, they reversed. If Pol does not reasonably represent the true sucrose, then its use in the evaluation of cane quality and quantity is not reliable, especially when the result is based on monetary value. By using the available data, we could see that by using the true sucrose instead of Pol, the payment in Standard Tons amounts to 8.7% to the original total payment. (Table 6)

CONCLUSION

1. Although polarization reading (Pol) is being used as a simple tool in routine control, it should not be taken as sucrose (true sucrose).
2. As polarization of an impure sugar solution could be affected by other optically or non-optically active non-sugars, there is no definite relation between Pol and true sucrose.
3. The main optically active non-sugars are dextrose and levulose. The D/L ratio in juice, as well as in sugar products, is not a constant. It may be varied by physiological reactions in the

cane, in the manufacturing process; or during storage of sugar products.

4. D/L is only one of the factors that may influence the Pol. Other non-sugars also affect Pol reading considerably.
5. The yield of sugar depends on actual sugar content in cane. If Pol does not rightly/reasonably show the actual sugar content, the evaluation based on Pol could be very misleading.
6. If cane is paid by sugar content, and the sugar content is based on Pol which may have wide discrepancy to sucrose, then either the cane producers or cane processors might suffer unjustifiable losses, especially under abnormal conditions.

ACKNOWLEDGEMENT

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TABLE 1. Dextrose/Levulose ratio of Raw Sugars.⁶⁾

Source (country)	Cargo #	D/L ratio
A	1	0.96
	2	0.87
	3	0.98
	4	1.00
	5	1.00
B	1	0.82
	2	1.16
	3	1.21
C	1	1.29
	2	1.04
D	1	1.00
	2	2.13
	3	1.86
	4	1.00
	5	1.25
E	1	0.78
	2	1.00
F	1	1.32
	2	1.50
	3	1.13
	4	1.00
	5	1.00

Table 2. Pol and Sucrose of some cane varieties.⁸⁾

Cane Variety	43-47	45-184	44-154	34-120	36-105	290	44-155	44-101
Campaign 1950								
Pol	10.44	9.72	7.59	9.27	-	8.94	10.92	11.01
Sucrose	10.63	10.02	7.81	9.41	-	9.13	11.14	11.12
Sucrose-Pol	+ .19	+ .30	+ .22	+ .14	-	+ .19	+ .22	+ .11
Campaign 1951								
Pol	9.31	8.05	7.40	8.00	8.31	7.27	10.44	10.28
Sucrose	9.43	8.19	7.60	8.26	8.50	7.37	10.66	10.37
Sucrose-Pol	+ .12	+ .14	+ .20	+ .26	+ .19	+ .10	+ .22	+ .09

Table 3. Pol and Sucrose of new and old cane varieties.

	New Variety L-6025			Old Variety CP-5268		
	Pol	Sucrose	Suc-Pol	Pol	Sucrose	Suc-Pol
1970						
1022	16.75	16.58	- .17			
1023	16.46	16.42	- .04			
1024	16.09	15.87	- .22			
1026A	16.51	16.38	- .13	13.96	14.10	+ .14
1026B	17.76	17.66	- .10	13.90	14.10	+ .20
1027	17.78	17.73	- .05	14.80	14.86	+ .06
1028	18.16	17.12	-1.04	13.68	13.70	+ .02
1103	17.34	17.12	- .22	15.26	15.23	- .03
1105	18.45	18.20	- .25	15.58	15.61	+ .03

Table 4. Sucrose, Dextrose and Levulose of Cane Juice.
(before the frost of Nov. 23, 1970)

Sample	Cane Variety	Pol	Invert.	Suc.	Dext.	Levu.	D/L	D+L	Invert. -D-L	Suc. - Pol
1022	L-6025	16.75	0.61	16.44	0.261	0.161	1.62	0.42	0.19	- .31
1026A	L-6025	16.51	0.63	15.81	0.246	0.175	1.41	0.42	0.21	- .70
1026B	CP-5268	13.96	1.14	14.44	0.574	0.456	1.26	1.03	0.11	+ .48

Table 5. Sucrose, Dextrose and Levulose of Cane Juice.
(after the frost of Nov. 23, 1970)

Sample	Cane Variety	Pol	Puri.	Inv.	Suc.	Dext.	Levu.	D/L	D+L	Inv. -D-L	Suc. -Pol
1130A	L-6025	13.16	83.29	1.14	13.23	.228	.218	1.05	.45	.69	+ .07
1202A	"	15.58	86.08	1.44	15.43	.340	.329	1.03	.67	.77	- .15
1204A	"	16.11	90.00	0.99	16.09	.156	.116	1.34	.27	.72	- .02
1130B	CP-5268	12.20	79.22	1.84	12.00	.356	.353	1.01	.71	1.13	- .20
1202B	"	13.83	81.35	1.79	13.61	.398	.413	0.96	.81	.98	- .22
1204B	"	13.61	85.06	1.70	13.56	.336	.219	1.53	.55	1.15	- .05

Table 6. Difference in Pol/Sucrose to Standard Ton and Yield.

	Net Cane, ton	Normal Juice			Standard Cane, ton	Theo. Recovery (#)	Yield (#)		
		Bx	Pol	Pur.			/gross cane	/net cane	/stand. cane
on Pol	56,133	16.25	12.94	79.64	62,453	182	158	176	158
on Sucrose	56,133	16.25	12.24	75.32	57,020	170	158	176	173
			0.70 (from Table 4)	4.32	5,433 x 8.53 = \$46,343.-	on net cane			15

PROBLEMS IN FULL SEEDING OF LOW GRADE STRIKES

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ABSTRACT

There are two fundamental problems in using the full seeding technique for low grade strikes. The first is determining the quantity of seed to be used and the second is selecting the proper supersaturation of the seeding point. Considerable controversy and confusion surround both of these problems. This paper gives a method of calculating the quantity of seed required and presents a graph correlating the quantity of seed with various sizes of "C" sugar crystal produced. It also presents a graph showing a safe seeding zone for various purities of graining material.

DISCUSSION

There is really no reason why there should be any confusion about the quantity of seed required. Providing the desired "C" sugar crystal size and the average particle size of the seed to be used are known, then the quantity of seed required can easily be calculated. Jenkins¹ gives the basic calculation. It has been modified below in order to take advantage of American practice of using apparent purities and brix.

Basis:

1,000 Ft³ "C" Massecuite

Assume:

"C" Sugar Crystal Size Desired = 0.35 MM
Seed Crystal of 0.015 MM (California & Hawaiian Fondant)
Purity of Seed = 100
Purity of "C" Sugar Crystal = 100
Purity of "C" Massecuite = 57.0
Purity of Final Molasses = 29.0
95 Brix "C" Massecuite

Let X = Percent of solids in Massecuite which enter "C" Sugar Crystals
C = Purity of "C" Massecuite
M = Purity of Final Molasses

Then:

$$X = \frac{100 (C-M)}{100 - M} = \frac{100 (57-29)}{100-29}$$

$$X = 39.44$$

At 95 Brix, 1 Ft³ Massecuite has 89,539# Solids
Solids in 1,000 Ft³ = 89,539#
Solids (and Sucrose, with 100 Purity Crystals) in "C" Sugar Crystals = 89,539# x 0.3944
Sucrose in "C" Sugar Crystals = 35,314#

$$\text{Wt. Seed} = 35,314\# \frac{(0.015)^3}{(0.35)^3}$$

$$\text{Wt. Seed Required for 1,000 Ft}^3 \text{ of "C" Massecuite} = 2.78\#$$

The use of apparent purities and brix introduces a small error into the result but this error is small compared to that usually caused by uncertainties about the true average particle size of the seed. In spite of these errors, the calculation gives results which are accurate for all factory operations. As can be seen, the quantity of seed required depends upon the particle size of the seed, the size of the "C" sugar crystals desired, the purities of the "C" massecuite and the final molasses and the brix of the "C" massecuite.

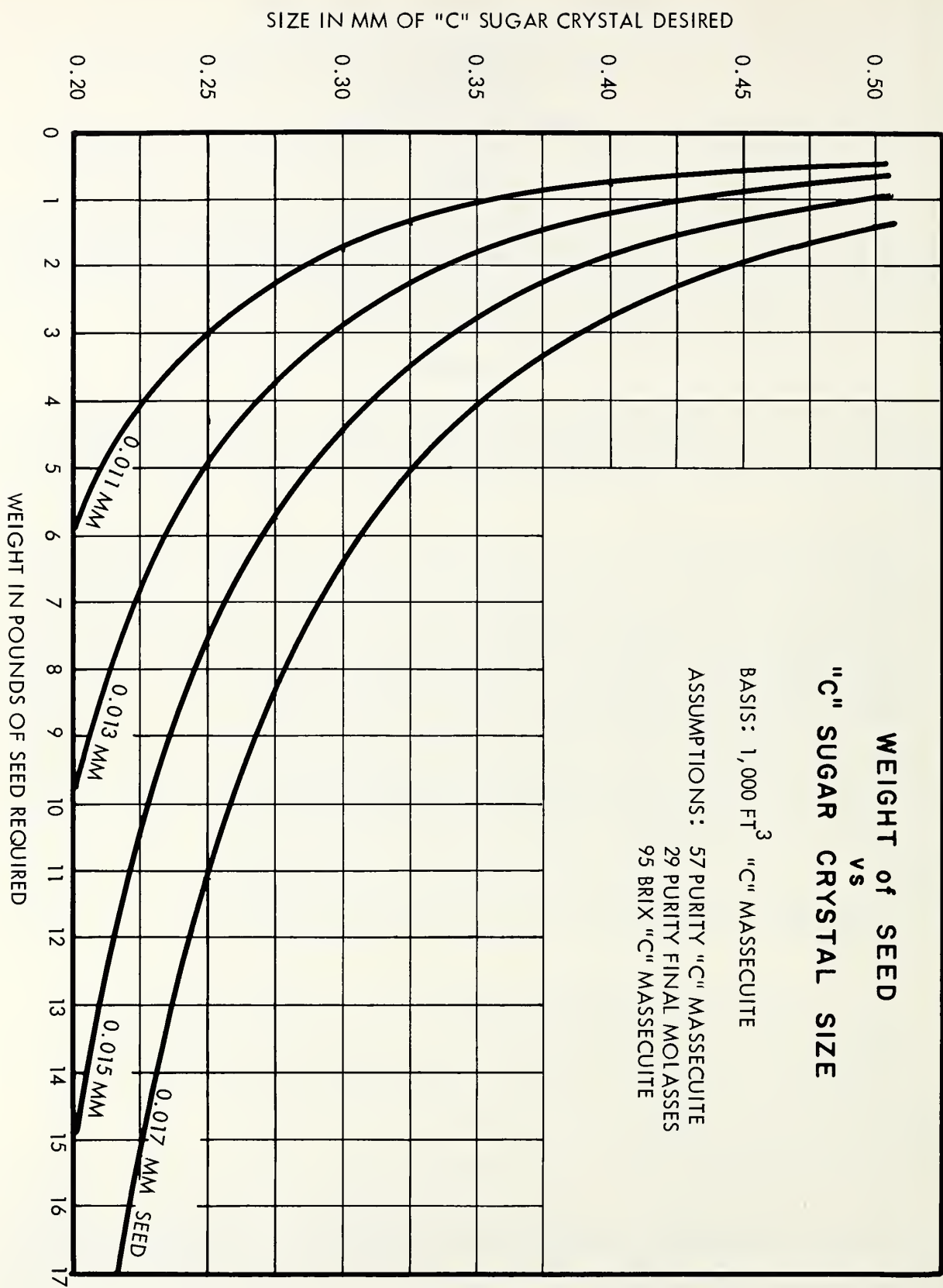
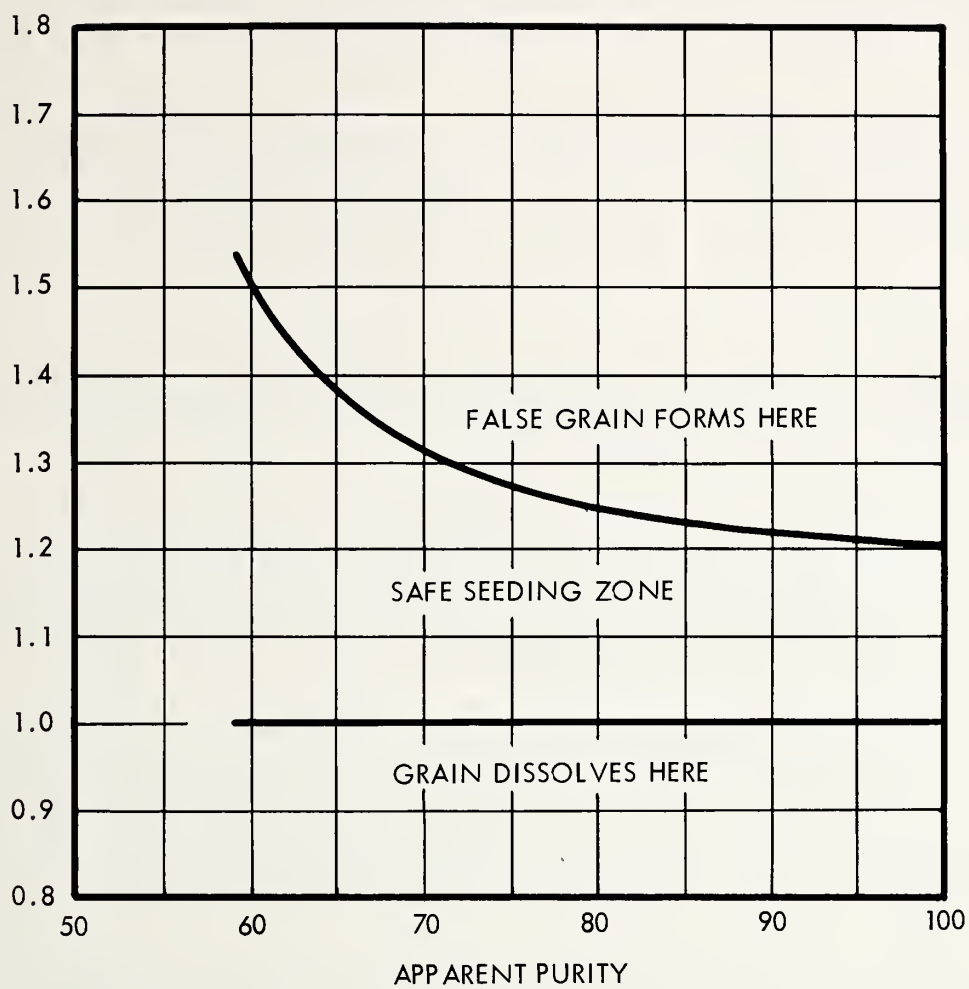


FIGURE I



LOCATION OF SAFE SEEDING ZONE

FIGURE 2

In Louisiana, it is common practice to use fondant sugar produced by the California & Hawaiian Sugar Company for seeding low grade strikes. This fondant is supposed to be approximately 15 microns in particle size, but there is obviously some variation from time to time. Figure 1 shows a graph correlating the quantity of fondant seed required for various seed particle sizes and "C" sugar sizes. This graph was prepared using seed quantities calculated by the method given above.

There is considerable discrepancy between the published quantity of seed required and the quantity of seed indicated by Figure 1. Part of this discrepancy can be accounted for by variations in the average particle size of the seed used, and by variations in the average particle size of the "C" sugar produced. Most of the discrepancy, however, is caused by confusion about the difference between shock seeding and full seeding.

In shock seeding, the graining charge is brought to a relatively high supersaturation and a quantity of crystals are introduced. These crystals then cause a large quantity of additional crystals to form in the graining material. In full seeding, however, a carefully measured quantity of seed crystals is introduced into a graining charge of relatively low supersaturation. No additional crystals are ever produced in the pan. The number of crystals which appear in the finished "C" massecuite equal the number of seed crystals introduced at the time of seeding. Many of the published articles on graining of low grade strikes do not properly differentiate between the shock seeding and the full seeding technique, and this is a cause of much of the confusion surrounding the quantity of seed required for full seeding.

In my own personal experience, excellent results have been achieved by using the quantity of C & H fondant indicated by the 15 micron particle size line on the graph of Figure 1, and I recommend that quantity for first efforts. If the "C" sugar crystals produced in actual practice are too small, then it would be necessary to reduce the quantity of seed used. Conversely, if the crystals are too large, it would be necessary to increase the quantity of seed.

The second major problem in full seeding of low grade strikes is selecting the proper supersaturation at which to seed the strike. The published literature is rife with detailed discussion of different supersaturation zones which have little actual application in sugar factory work. In full seeding, all operations are carried out in a "safe" zone, which is essentially the same as the metastable zone. If the graining charge is concentrated above the safe zone there is danger of forming conglomerates or false grain. If the supersaturation is allowed to fall below the safe zone, there is danger that grain will be dissolved. The safe zone depends upon the purity of the material being grained and the composition of non-sugars therein.

Figure 2 shows the safe seeding zone of supersaturation for various purities. It has been constructed through actual factory experience, and it is not in accord with the results of many recognized experts in the field. Ziegler² has stated that a supersaturation of 1.5 is the critical point in material of a wide range of purities above which false grain occurs. Weber³, in his later writings, publicized the figure of 1.4 as the upper limit of the safe zone for all purities. I have found, however, that this safe zone depends considerably upon the purity of the material being grained, and will vary from approximately 1.25 with 80 purity material to approximately 1.5 with 60 purity material.

This confusion surrounding the upper limit of the safe zone will probably never be completely cleared up. The non-sugar composition of cane juices vary greatly from one cane producing area to the other and even from one year to the next in the same area. These variations certainly affect the solubility of sucrose in syrups and molasses and give different results to different technologists. Factory operations are very much different from laboratory work. Each vacuum pan is different and results obtained with one pan can be different from those obtained with another. Commercially available supersaturation instruments measure the supersaturation at only one point in a pan. Other points in the pan usually have a different supersaturation from that indicated by the instrument. Poor circulation and dead pockets in a pan also cause erratic results. These different pan characteristics help explain the different results obtained by different sugar technologists.

Best results are obtained by seeding near the center of the safe zone shown in Figure 2. After the grain has been brought together it is then possible to raise the supersaturation nearer to the upper limits of the safe zone to get faster boiling in the pan.

One important point should be emphasized. As soon as the charge is seeded the purity of the graining material liquid begins to drop. Boiling point elevation instruments are affected by purity of the material so that they start to become inaccurate as soon as the seeding has occurred. They are useful only to determine the proper point at which to seed, and for some 10 minutes thereafter. After that time they are too inaccurate to be relied upon, and the pan boiler must rely on his own experience to carry the pan in the safe zone.

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Alfred L. Webre, Jr. and G. Aleman

ABSTRACT

This paper is a continuation of the one presented by Webre at the Taiwan Meeting of the ISSCT in 1968 entitled "An Absolute Criterion of Millwork?". (See P. 1595 of the Proceedings of that Meeting). In that paper it was shown that the brix of Absolute Juice has a strong effect on millwork. That is, as the brix drops the extraction rises and the Milling Loss and other criteria drop. This is quite understandable since the additional water is, in effect, a perfect imbibition water applied uniformly to the interior of the cells of the cane. It is quite different from the imbibition water applied at the Mill, which makes very little penetration beyond the first two or three inches of the bed of bagasse. It is the purpose of the present paper to examine the possibility of putting this phenomenon to practical use. Naturally, this must be limited to the areas where irrigation is used, either conventionally or subterraneously as in Florida.

In 1968 Webre presented a paper at the Taiwan Meeting of the ISSCT entitled "An Absolute Criterion of Millwork?". (See P. 1595 of the Proceedings of that Meeting). In that paper it was shown that the brix of Absolute Juice has a strong effect on millwork. That is, as the brix drops the Extraction rises and the Milling Loss and other criteria drop. This is quite understandable since the additional water is, in effect, a perfect imbibition water applied uniformly to the interior of the cells of the cane. It is quite different from the imbibition water applied at the Mill, which makes very little penetration beyond the first two or three inches of the bed of bagasse. It is the purpose of the present paper to examine the possibility of putting this phenomenon to practical use. Naturally this must be limited to areas where irrigation is used, either conventionally or subterraneously as in Florida.

Presented herewith is Fig. 1, repeated from the original paper. Its derivation was fully explained in that paper, so will not be repeated here. Suffice it to say that it is a family of curves, one curve for each Imbibition/Fiber ratio. These curves show the relationship between Brix of Absolute Juice, more conveniently expressed in this case as the Pol/Water ratio, and the theoretical minimum Milling Loss achievable with ideal equipment. To refresh your memory, Milling Loss is defined as Pol % Fiber in Bagasse. The theme of the Taiwan paper was that by comparing the theoretical Milling Loss with the observed Milling Loss one could obtain a criterion of mill performance in absolute terms.

To obtain a practical case we examined the daily technical data of Glades Sugar House for the 1966/67 crop. We chose that crop since it was the last one in which Absolute Juice was reported. In subsequent crops Normal Juice was reported for reasons internal to the organization. In making our examination of the data, the objective was to compile records of the theoretical ML and compare these with the reported ML. We found that the data were quite good over a rather wide range of grinding rates. And so it allowed us to include all days where grinding rates fell between 350 and 390 tons per hour. Table 1 is presented herewith, showing the appropriate data for the grinding rates selected. All figures are copied or calculated from the Daily Technical Reports except the last column; these figures come from Fig. 1 of this paper. Perhaps we should point out that these analyses refer to Absolute Juice.

Fig. 2 represents the results, the comparison of theoretical ML with reported ML for that crop at Glades. This graph has more than one use, but we will limit it to the scope of this paper which will become apparent below. In passing we should point out that the line should really be curved, so as to pass through the 0-0 coordinates. However, the useful part of the curve is very close to a straight line of the formula: $ML = 4.35 + 1.79 ML(T)$, where $ML(T)$ is theoretical ML. Perhaps we should also point out that, although the graph shows a very strong direction and configuration, there is a tendency for a bit of scattering of the points. This is readily understood if you consider the method necessarily used in taking the sample of bagasse. The analysis itself is quite good, and is direct; but the sampling leaves something to be desired, as it does in all sugar houses. It is a grab sample, taken once every two hours and represents the grinding of one truckload out of 40-odd. Obviously there is room for error, and that error manifests itself in the scattering of the points. We chose our scale precisely to diminish the scattering effect and allow us more accuracy in determining the position and direction of the curve.

Going to a specific day in order to examine a concrete case, let us consider December 30, 1966 with the following data picked out of Table 1.

Bx	Water	Pol	Pol Water	ML	I/F	TPH	ML(T)
15.98	84.02	12.73	.1517	8.17	1.39	363	2.15

To simplify the next steps, we will assume 13.0% fiber and 87.0% Absolute Juice.

Now, consider 1 Ton of this cane:

Fiber	=	.13 x 2000	=	260 lbs.
Abs. Juice	=	.87 x 2000	=	1740 lbs.
Bx Solids	=	.1598 x 1740	=	278 lbs.
Pol Solids	=	.1273 x 1740	=	222 lbs.
Water	=	.8402 x 1740	=	1462 lbs.

Now let us irrigate the field and let the cane pick up "imbibition water" to the extent of I/F = 100, or 260 lbs.

Then,

Original Water	=	1462 lbs.
Add		<u>260 lbs.</u>
New Condition	=	1722 lbs.

And,

$$\frac{\text{Pol}}{\text{Water}} = \frac{222}{1722} = .1288$$

Since the original data showed that on that day the factory used L/F = 1.39, we go into Fig. 1 and find that ML(T) should be .1825. By Fig. 2 we determine that if this new cane were ground we should expect an observed ML = 7.62. Now we must compare the Milling Loss as actually observed on December 30 with the Milling Loss we would have obtained if we had ground the irrigated cane.

ML as reported	=	8.17
ML of irrigated cane	=	<u>7.62</u>
Difference	=	0.55

This figure of 0.55 represents additional sugar that would be extracted from the irrigated cane. So, on a ton of such cane we would extract extra sucrose as follows:

$$260 \text{ lbs. fiber} \times .0055 \text{ ML} = 1.43 \text{ lbs. sucrose}$$

In the Boiling House we would retain perhaps 88% of that:

$$0.88 \times 1.43 = 1.26 \text{ lbs. sugar in the warehouse.}$$

Allowing 7.8¢ per lb.:

$$1.26 \times 7.8 = 9.8¢ \text{ per ton cane ground, net profit.}$$

Please note that this money is pure profit to the factory except for the cost of warehousing and shipping. All other costs have been paid.

Now, let us consider the dim side. Of most concern to the factory man will be his boiler and evaporation capacity. And it cannot be denied that an additional increment of each would be required for optimum results. However, we should point out that if the factory is truly short, then the imbibition water at the mill could be advantageously reduced in favor of the water added by irrigation. As indicated at the beginning of this paper, the water taken up by the cane in the field is infinitely more efficient than the water added at the mill, and so can be regarded as better than a mere substitute for it. In fact, if we could induce the cane to pick up water to the extent of 200% fiber, such as many of us use at the mill for normal imbibition, we could dry-grind and still do better than grinding the cane unirrigated and using that water on the mill.

Moving into the agricultural area, a few preliminary points should be made. First, it is very obvious that such a procedure as we are suggesting would require good management. Timing is all important; the irrigation must be done allowing sufficient time for the cane to pick up the required water plus sufficient time for the field to drain so that equipment can enter without damaging the stand. Needless to say, the procedure should only be carried out in cool weather. If the weather is hot and water is pumped onto the cane, the latter will enter its growing cycle with disastrous results. We should also point out that since the cane is absorbing water, its weight will rise, increasing the tons of cane per acre. But by dilution the sucrose in normal juice drops. The net result will be no change in payment to the farmer. And the tons of sugar per acre should remain essentially unchanged.

The most important item, of course, is pumping cost. And since the factor is the beneficiary of the procedure we should like to suggest that it bear the brunt of this cost. At this stage we cannot venture an opinion as to what it would be dollarwise; until it is actually tried out there is no way of telling how much water would have to be pumped. But since there is additional sugar to the extent of almost 10¢ per ton of cane, there seems to be room for covering this cost, provided that there is a good stand of cane that can fully utilize the water pumped into the field.

As indicated at the beginning of this paper, it has been our purpose to point out this possibility and examine the economics. Having done this, we would suggest that the next obvious step would be to try it out on a small scale, to establish the parameters, if nothing else. How much water need be pumped; how long must it be maintained, what drainage time must be allowed. Once these are established the practicality can be determined from the farmer's point of view, and a decision made as to whether the complications are worth while. Then arrangements should be made for a factory run of this cane, say about 1/2 to 3/4 hour, to see if there are any unusual grinding problems with it. During this period several samples of first expressed juice and of bagasse should be taken and analysed so that a good appraisal can be made. Once all of these are done, Management of both farm and factory will be able to make a decision in regard to pushing this somewhat unconventional suggestion.

TABLE 1

Date	Brix	Water	Pol	Pol Water	ML	I/F	TCH	ML(T)
11/23	14.50	85.50	11.20	13.10	6.70	160	367	1.33
11/24	14.73	85.27	11.40	13.39	7.04	159	362	1.38
11/25	15.12	84.88	11.77	13.89	7.24	144	372	1.80
11/28	15.95	84.05	12.58	15.00	7.60	131	371	2.38
11/29	15.52	84.48	12.16	14.40	6.96	144	364	1.87
11/30	15.87	84.13	12.66	15.05	6.35	148	373	1.85
12/1	15.75	84.25	12.56	14.92	6.65	159	382	1.55
12/3	15.42	84.58	12.12	14.32	6.61	177	352	1.15
12/5	15.02	84.98	11.69	13.77	5.73	163	375	1.35
12/8	16.56	83.44	12.95	15.55	6.53	184	363	1.12
12/9	16.46	83.54	12.78	15.30	7.01	162	375	1.51
12/12	15.51	84.49	12.28	14.52	7.57	174	386	1.20
12/13	15.72	84.28	12.45	14.80	6.97	183	352	1.10
12/14	15.60	84.40	12.46	14.79	7.59	174	380	1.25
12/15	16.21	83.79	13.13	15.70	7.49	157	368	1.70
12/16	16.43	83.57	13.34	16.00	7.51	156	373	1.75
12/17	16.57	83.43	13.25	15.90	8.37	170	379	1.40
12/21	16.86	83.14	13.49	16.24	8.57	149	384	1.95
12/26	16.85	83.15	13.33	16.06	9.31	175	350	1.30
12/28	15.49	84.51	12.38	14.65	8.12	141	366	2.00
12/30	15.98	84.02	12.73	15.17	8.17	139	363	2.15
1/1	15.39	84.61	12.11	14.31	8.45	133	379	2.20
1/4	15.62	84.38	12.54	14.89	7.94	146	376	1.90
1/5	15.36	84.64	12.45	14.73	7.73	157	375	1.60
1/6	15.57	84.43	12.84	15.23	7.54	149	352	1.85
1/9	15.90	84.10	12.94	15.40	7.71	132	373	2.40
1/10	16.00	84.00	12.94	15.41	8.13	146	366	1.95
1/11	16.00	84.00	12.96	15.43	7.94	142	386	2.10
1/13	15.87	84.13	12.89	15.32	7.76	142	383	2.05
1/14	15.80	84.20	12.70	15.10	7.86	125	383	2.65
1/15	15.92	84.08	12.73	15.15	7.51	148	385	1.90
1/24	16.04	83.96	12.97	15.47	8.40	147	382	1.95
1/25	15.59	84.41	12.60	14.95	8.35	143	370	2.00
1/26	15.64	84.36	12.61	14.98	8.15	137	369	2.15
1/27	15.59	84.41	12.42	14.75	7.96	136	361	2.20
1/28	16.07	83.93	13.07	15.59	8.94	129	363	2.55
1/29	16.52	83.48	13.43	16.10	9.41	140	371	2.25
1/30	16.50	83.50	13.52	16.20	9.24	144	390	2.10
1/31	16.40	83.60	13.44	16.09	8.53	155	382	1.75
2/1	16.53	83.47	13.68	16.40	8.50	146	384	2.10
2/2	16.72	83.28	13.88	16.68	8.85	150	372	2.00
2/4	16.31	83.69	13.31	15.92	9.16	141	389	2.20
2/10	16.55	83.45	13.74	16.50	8.66	128	384	2.75
2/12	16.73	83.27	13.77	16.55	8.56	134	355	2.50
2/15	16.85	83.15	13.93	16.77	8.71	121	377	3.15
2/16	16.90	83.10	13.94	16.79	8.43	125	387	2.45
2/17	17.05	82.95	14.14	17.08	8.71	147	364	2.15
2/18	16.93	83.17	14.02	16.88	8.48	148	374	2.10
2/20	16.90	83.10	13.93	16.80	8.19	139	382	2.40
2/24	16.21	83.79	13.41	16.02	7.27	154	352	1.80
2/27	16.83	83.17	14.00	17.00	8.16	127	370	2.90
2/28	17.41	82.59	14.43	17.50	8.09	174	352	1.45
3/1	16.75	83.25	13.77	16.55	8.16	143	352	2.20
3/2	17.62	82.38	14.49	17.60	8.82	150	363	2.10
3/3	16.96	83.04	13.91	16.77	9.24	141	358	2.30
3/5	17.11	82.89	14.06	17.00	9.14	143	366	2.25
3/6	17.08	82.92	14.14	17.13	9.43	147	363	2.15

TABLE 1 (con't)

<u>Date</u>	<u>Brix</u>	<u>Water</u>	<u>Pol</u>	<u>Pol Water</u>	<u>ML</u>	<u>I/F</u>	<u>TCH</u>	<u>ML(T)</u>
3/7	17.40	82.60	14.04	17.00	9.28	148	363	2.10
3/9	16.81	83.19	13.80	16.60	8.77	132	363	2.60
3/13	18.69	81.31	15.45	19.00	9.19	128	364	3.20
3/17	17.68	82.32	14.86	18.07	8.84	151	362	2.15
3/25	17.96	82.04	14.88	18.15	8.37	154	358	2.00
3/26	18.68	81.32	15.59	19.20	8.54	124	375	3.40

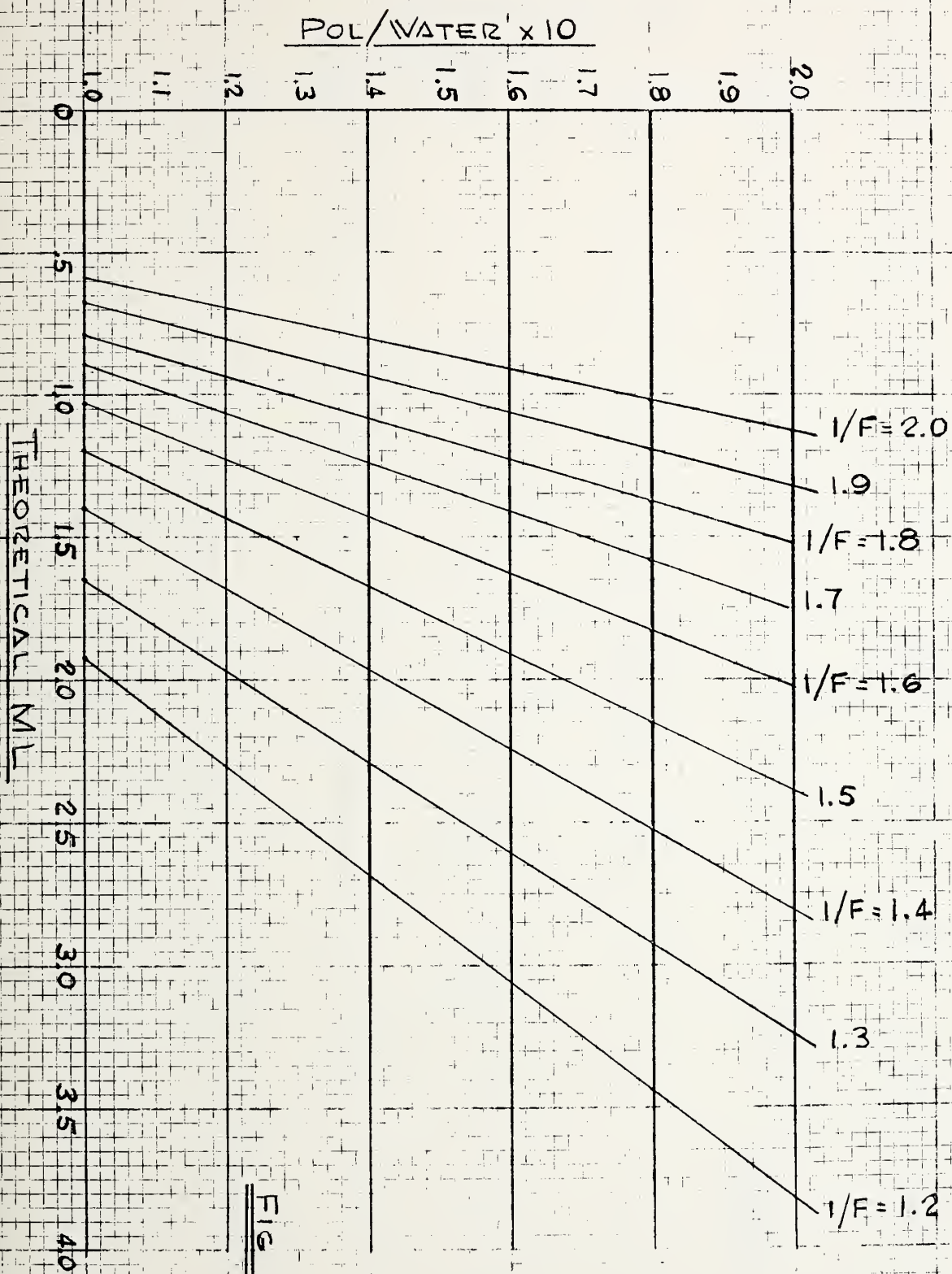


Fig 1

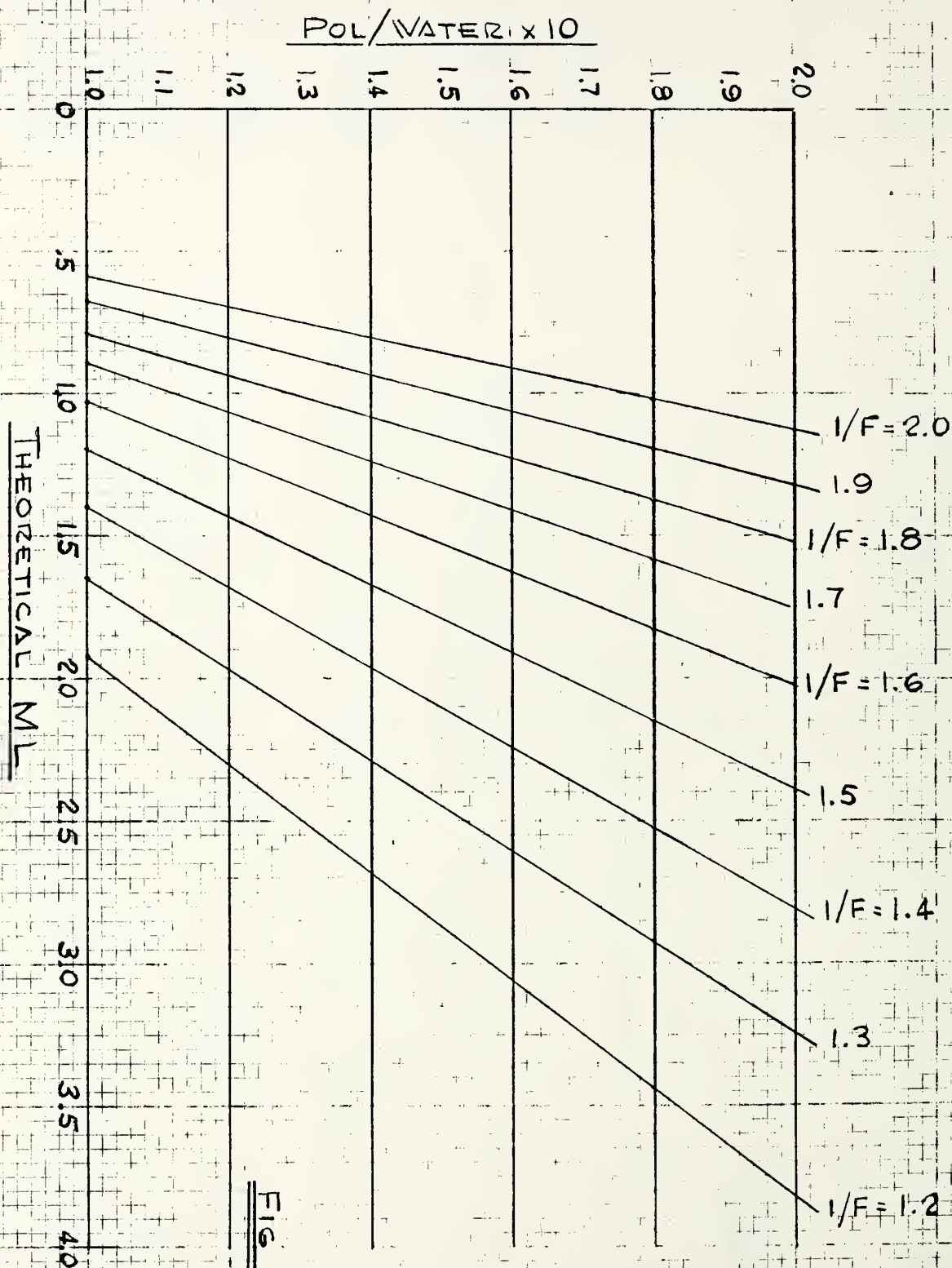


FIG. 1

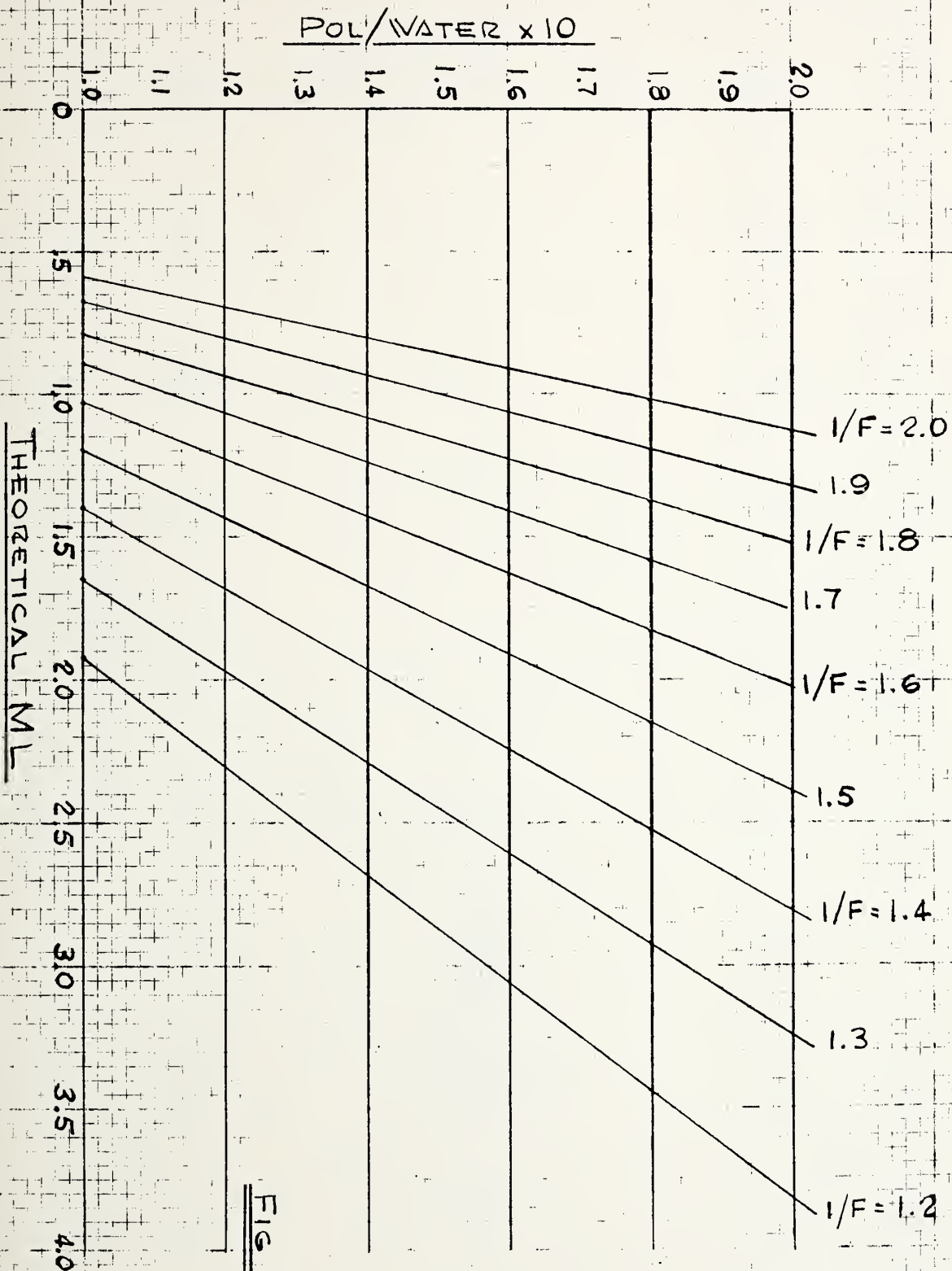
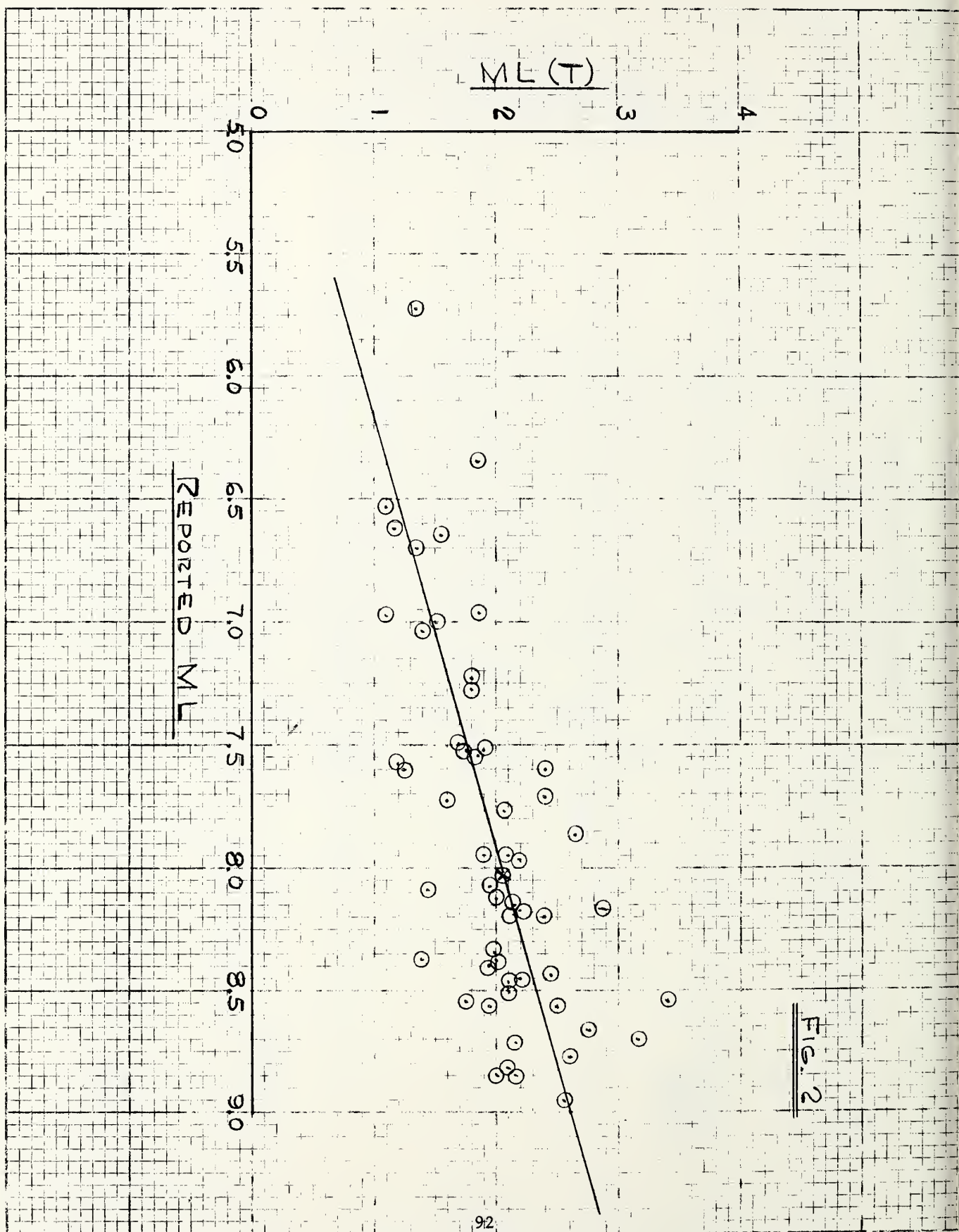


FIG 1



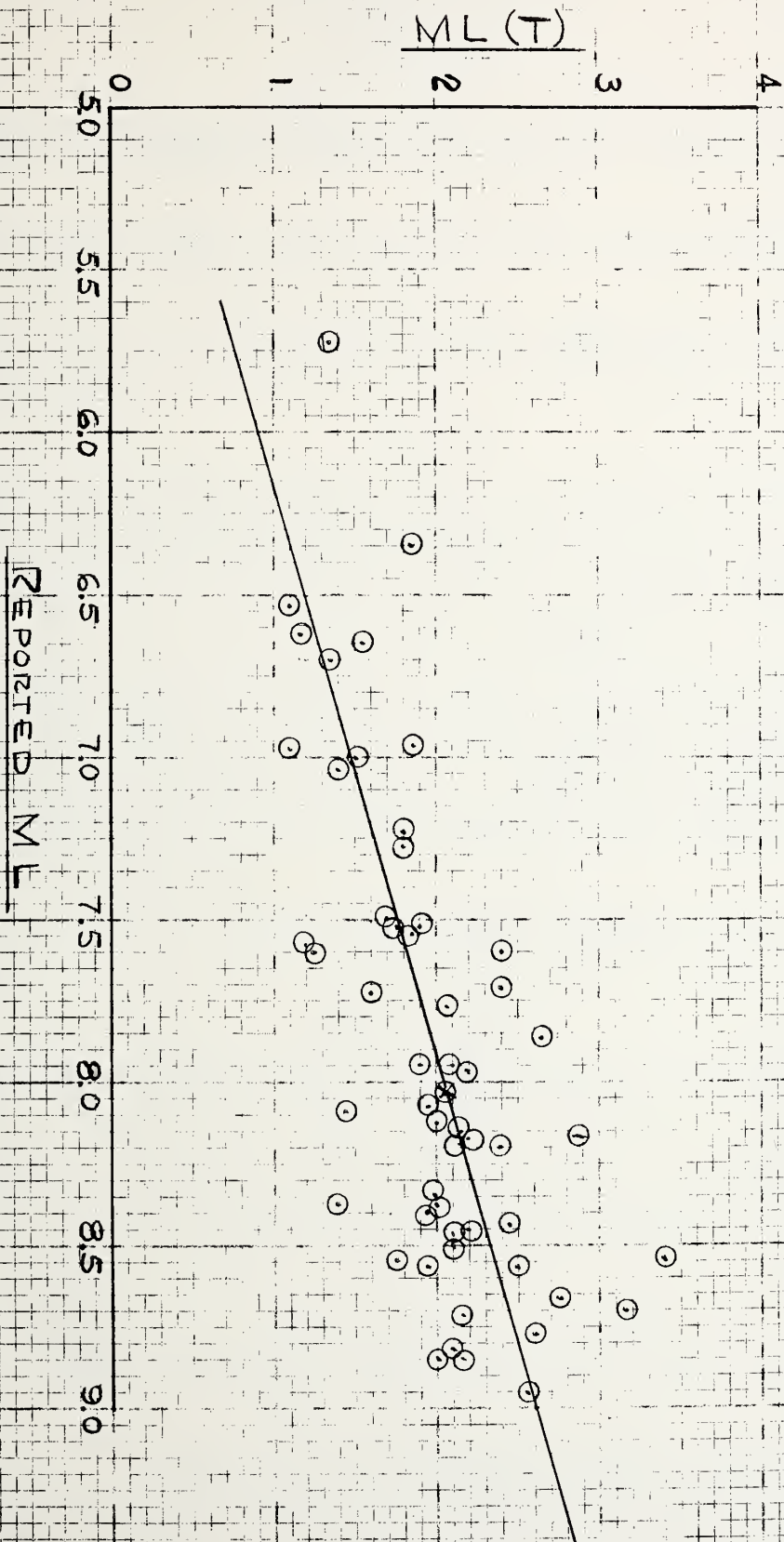
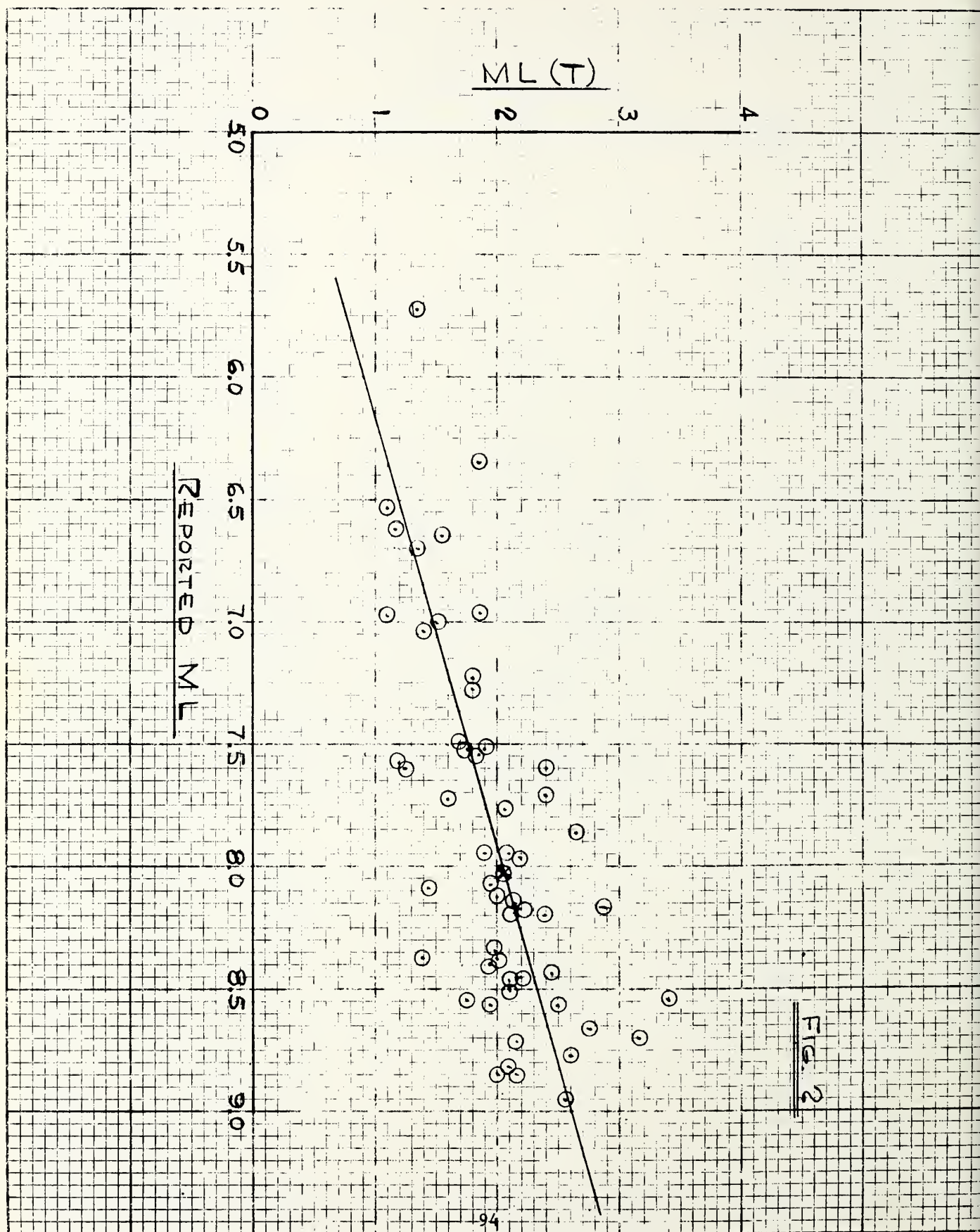


FIG. 2



GRADING VARIETIES FOR YIELD IN CLONAL PLOTS AND YIELD TRIALS

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ABSTRACT

A grading system used at the USDA Sugarcane Field Station, Houma, Louisiana, to estimate yielding ability of sugarcane varieties in clonal plots and replicated test is described. An experiment was conducted to test the effectiveness of selection for yield, based on grade, in clonal line trials and variety tests.

Visual yield estimates showed a consistent positive association with yield estimated by sampling or weighing whole plots. Grading varieties can be used to rapidly eliminate low yielding clones with little effort before taking more objective yield data.

Selection for yield in 2 m and 5 m clonal plots was moderately effective in isolating high yielding varieties for inclusion in replicated test. The results showed that while grading sugarcane varieties is no substitute for conventional methods for determining yield, it can be a useful supplement to accepted methods.

INTRODUCTION

Methods for measuring sugarcane yields have advanced from less precise systems of grading or sampling, to more precise methods of weighing whole plots, followed by exact statistical analyses. However, grading varieties by making visual estimates of yield is still important in the early stages of selection in all sugarcane breeding programs. Tens of thousands of varieties in single stools or thousands in clonal plots is too large a number, and plot size is too small, to obtain critical yield data. In the first selection stage, single stools of varieties are graded into only 2 classes. They are either selected or rejected. Later, more elaborate grading systems are used in clonal line trials.

Hogarth and Skinner (1) rejected visual yield estimates as a method for sampling yield in replicated variety trials. They made yield estimates by weighing 45 stalk samples and multiplying stalk weight by the number of stalks for each plot. This proved to be a less biased, more precise method. In their study, however, visual yield estimates were highly correlated with weighed plot yields and Skinner (4) described a grading system used in replicated yield tests in Queensland. At the USDA Sugar Station at Houma, varieties must be selected for replanting from replicated infield variety trials 2 months before the harvest season. It is difficult to obtain unbiased samples from this uncut cane. Also cutting at this early date may often bias final weighed yields in the plant and stubble cane of these tests. Grading varieties just before replanting remains the most practical means of selection, (Matherne, 3), at this testing stage.

This paper describes the grading system evolved at the USDA Sugarcane Field Station to visually select sugarcane varieties for yielding ability. The effectiveness of selection for yield by grade was also tested.

MATERIALS AND METHODS

System of Grading. Varieties are graded visually from 1 to 10 for estimated tons of cane per acre (T/A). Varieties that appear equal in cane tonnage to the standard variety (CP 52-68) are assigned a grade of 5. Numerical grades increase by 1 for each estimated 10% yield increment above the standard and decrease by 1 for each 10% yield increment below the standard (Table 1).

The grade yield is then adjusted to express sugar per acre (S/A). The adjustment is based on previous sucrose data or on brix or sucrose in the nursery or yield trial being rated. The yield grade is increased by 1 for each 10% increase in sugar per ton of cane above standard and decreased by 1 for each 10% decrease in sugar per ton of cane below the standard. CP 48-103 is the present sucrose standard. The adjusted yield grade becomes the grade for yield of sugar per acre for each variety (Table 1).

For example, a variety estimated at 90% of standard in yield with a sucrose of 120% of standard is rated $4 + 2 = 6$. Ratings sometimes occur outside the 60% to 150% of standard range provided by the rating scale. When varieties exceed this range, those below 60% of standard are grouped in class 1 and those above 150% are assigned grades above 10.

Varieties are rated independently by 4 agronomists, at 3 different times during the growing season in 1) early spring after establishment of stand; 2) mid-summer after tillering; and 3) late summer or early fall just prior to selection or harvest. The ratings, usually in very good agreement, are averaged. Emphasis is placed on the final rating at selection time. Early ratings are considered, however, and are particularly helpful if cane is severely lodged by hurricane or rainstorm making late ratings difficult.

Experimental procedure. Clones used in the study were 95 randomly selected progeny of a cross between CP 52-1 x CP 52-11, the parent clones, and commercial varieties CP 52-68 and CP 48-103. Plant material of the 95 clones were grown as 2 m plant cane clonal plots (1966) and 5 m plant and stubble cane clonal plots (1967-68). Finally, the clones were grown in plot size in a 3-replicate simple lattice yield trial in plant cane and first stubble cane (1968-69).

Three methods of measuring yield were used in the study. Firstly, just before harvest an estimate of yield of tons of cane per acre (T/A) and sugar per acre (S/A) was made by grade assignment as described above. These visual yield estimates are called graded yields. Secondly, cane yield in clonal plots was estimated by weighing 10 stalk samples and multiplying stalk weight by the number of stalks for each plot. Sugar per ton of cane was calculated according to standard methods of the Houma Station recently reviewed by Legendre (2). Yield of S/A was obtained by multiplying sugar per ton of cane by T/A. These calculated yield estimates are sampled yields. Thirdly, yield was determined from whole plot weights in the replicated tests. These yield estimates are called weighed yields.

Correlation coefficients (r) were calculated between graded yield and either sampled or weighed yield at each different stage of testing. Correlation coefficients were also calculated between graded and sampled yield in clonal plots and weighed yield in replicated test.

EXPERIMENTAL RESULTS

Graded yield vs sampled or weighed yield in the same stage. There was a significant positive association between graded yield and sampled weighed yield for both T/A and S/A (Table 2). Correlation coefficients of .689**, .614**, and .728** were obtained between graded and sampled yields T/A and .735**, .635**, and .672** for graded and sampled yields S/A in 2m, 5 m plant and 5 m stubble plots, respectively.

Graded and weighed yields were also positively associated in the replicated test. Correlation coefficients of .724** and .810** were obtained between graded and weighed yields T/A and .794** and .763** between graded and weighed yields S/A in the plant and stubble test, respectively. The results suggested a moderately close positive association between graded yield and both sampled and weighed yields at each of the test stages.

Scatter diagrams (Figs. 1 and 2) show the association between graded yield T/A in clonal plots and weighed yield T/A in replicated test and between sampled yield T/A in clonal plots and weighed yield T/A in replicated test.

The sampled yield of the standard in the 5 m stubble clonal plots was 40.0 T/A (Fig. 1). An r value of .728** was calculated between graded and sampled yields. The 95 clones ranged from 3.27 to 59.31 T/A. The graded yields were less variable. No clone was rated superior to the standard although 5 clones outyielded the standard by at least 25%. There were 17 clones that equalled the standard in T/A. All 17 were graded into classes 4 or 5. All varieties graded into classes 1 to 3 were lower than standard in yield. Clones in the modal class, 4, showed the most variability in tonnage. Thirty of the 42 clones were lower in tonnage than standard, but 12 were higher and 3 of these 12 clones produced sampled yields of over 50 tons.

In the stubble replicated test the weighed yield of the standard was 33.5 T/A (Fig. 2). An r value of .810** was calculated between graded and weighed yields. The mean weighed yield of the 95 clones ranged from 8.0 to 38.8 T/A and mean graded yield averaged from 1 to 5.3. None of the 95 clones significantly outyielded the standard in cane tonnage. Seven clones equalled the control in yield and all of these were rated from 4.3 to 5.3. None of the clones rated in classes 1 to 4.0 equalled the control in T/A.

The associations between graded and sampled yields of S/A in the 5 m stubble clonal plot and between graded and weighed yields of S/A in the stubble replicated test are presented in scatter diagrams (Fig. 3 and 4).

The yield of sugar per acre (S/A) of the standard was estimated at 8000 lbs (weighed yield T/A x pounds sugar per ton) in the clonal plots. An r value of .672** was obtained between graded and sampled yields (Fig. 3). Ten clones equalled standard in sampled yield of sugar. One of these clones was rated in class 2 and 3 were rated in class 3. These clones produced higher cane tonnage than predicted by grading for yield. The 3 highest yielding clones (10,000 lbs S/A or more) were graded in classes 4 or 5.

In the stubble replicated test the standard was 7791 lbs S/A. A high r value of .763** was obtained when graded and weighed yields were correlated. Only a single clone (No. 27) yielded significantly more S/A than did the standard. This clone had been assigned the highest commercial grade, 6, in the test.

Graded and sampled yields in clonal plots vs weighed yield in replicated test. Correlation coefficients between graded and sampled yields in clonal plots and weighed yield in replicated test for T/A and S/A are presented in Table 3. There were significant positive associations between graded and sampled yields in both 2 m and 5 m clonal plots and weighed yield in replicated test, indicating that selection for yield in clonal plots using graded or sampled yields would be effective.

The results suggest that selection for cane tonnage could be practiced even in the 2 m clonal plot stage. Selection, of course, could not be rigid in view of the magnitude of the r values, 0.390** for

graded and weighed yields and 0.499** for sampled and weighed yield. Although the difference was not significant, the association between sampled yield in the 2 m clonal plot and weighed yield in replicated test was closer than between graded yield in 2 m clonal plots and weighed yield in replicated test. This was also true in the 5 m plant cane clonal plots. Here the r value between graded yield in the clonal plot and weighed yield in replicated test was .361** but was .525** between sampled yield in clonal plots and weighed yield in replicated test. The difference was significant (Fisher's 2 test). The highest positive association between T/A in clonal plots and replicated test was at the 5 m stubble clonal plot stage. The r value for grade and weighed yield was .635** and for sampled yield and weighed yield was .574**. The r values were not significantly different (Table 3).

S/A yield, estimated by either sampling or grading in clonal plots, showed a more consistent positive association with weighed yield in replicated test than did T/A yield (r values ranged from .522** to .612** for S/A and from .390** to .635** for T/A). The results suggested that selection for S/A practiced in 2 m or 5 m clonal plots would be effective in isolating high yielding clones for inclusion in yield trials.

Scatter diagrams were prepared showing the association between graded yield (T/A and S/A) in the 5 m stubble clonal plot and weighed yield of the 95 clones in replicated test (Fig. 5 and 6). Seven of the clones equalled the standard in T/A in weighed replicated yield test. If selection had been practiced for grades 4 and 5 in the 5 m clonal plot 6 of these 7 clones would have been selected for further consideration and 1 would have been discarded. The frequency of clones that yielded equal to standard in the weighed replicated test would have been raised from 7 in 95 (7.4%) to 6 in 56 (10.7%) (Fig. 5).

Converting graded yield for T/A to graded yield for S/A in the 5 m stubble clonal plots would permit the quick elimination of even more inferior clones (Fig. 6). If selection were practiced for S/A grade classes 4 and 5, 14 clones would have been selected for planting in replicated test. Both of the 2 clones that equalled standard in S/A would have been selected. The frequency of clones equal to standard in S/A, then, would be raised from 2 in 95 (2.1%) to 2 in 14 (14.3%) an appreciable selection gain.

DISCUSSION

There was a close positive association between subjective visual yield estimates and more objective yield measurements at all the different test stages during all years in which the study was conducted. This may surprise workers in other areas. In fact, certain conditions peculiar to Louisiana probably aid the selector in making visual yield estimates. Sugarcane is planted in the fall of the year and must over-winter underground which often results in less perfect stands than in more tropical areas where cane germinates immediately. These differences in stand among varieties are very noticeable particularly in early test stages. Significantly, stalk number is the component of yield most closely correlated with visual, sampled, or weighed cane yields (data not shown). Also, sugarcane remains erect in Louisiana throughout most of its comparatively short growing season. Visual yield estimates are usually possible in reasonably erect cane up to or very near harvest time. This undoubtedly permits a more accurate visual appraisal of other important yield components, such as stalk diameter and stalk height, than is possible in areas where cane lodges severely months before it is harvested.

The results suggested that in Louisiana selection for yield based on grade would be effective in isolating high yielding clones. The results showed that clones graded 1, 2, or 3 for T/A (20% or more below standard) could probably be immediately rejected with little loss of valuable genotypes. Cane tonnage grades of selected clones can then be adjusted, with available brix or sucrose data, to S/A grade. Apparently, clones with S/A grades 20% below standard (1, 2, or 3) could also be immediately rejected. Attention, could then be centered on the remaining clones and more objective yield estimates need be made only on these, saving considerable time and effort.

The results showed that it would be possible to begin selection for yield as early as the first line trial (2 m plot) stage in the breeding program. R values for yield in the 2 m plot were significant though not of a magnitude that would permit rigid selection. Yield in the 5 m plots was more closely associated with yield in replicated test. Selection in the plant and ratoon 5 m plots could be more rigid than in 2 m plots and would be more effective in isolating high yielding clones for inclusion in yield trial.

Although r values between either graded or sampled yields in clonal plots and weighed yield in replicated test were not significantly different in this study, it does not necessarily follow that the 2 methods would offer equal precision in selection for yield (1). Probably, it would be better to assume that some precision could be gained by sampling yield of clones in clonal plots that meet the minimum grade standards as discussed previously.

Visual yield estimates are not intended and can never replace accepted objective methods for measuring sugarcane yield. The results of this study indicate, however, that grading sugarcane varieties for yield can be a useful timesaving supplement to these approved methods.

ACKNOWLEDGEMENT

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Table 1. Grade assignments for estimated cane yield (T/A), grade adjustments for estimated sugar per ton of cane, and final grade assignments for estimated sugar per acre yield (S/A).

Cane Tonnage										
Grade	1	2	3	4	5	6	7	8	9	10
Est. Cane Yield (% standard)	60	70	80	90	100	110	120	130	140	150
Sugar per Ton										
Grade (adjustment)	- 4	- 3	- 2	- 1	0	+ 1	+ 2	+ 3	+ 4	+ 5
Sucrose (% standard)	60	70	80	90	100	110	120	130	140	150
Sugar per Acre										
Grade	1	2	3	4	5	6	7	8	9	10
Sugar per Acre (% standard)	60	70	80	90	100	110	120	130	140	150

Table 2. Correlation coefficients (r) between graded and sampled yields in 6 and 15 foot clonal plots and between graded and weighed yields in replicated test.

	: r value for graded vs sampled yield			:: r value for graded vs weighed	
	: in clonal plots of:			:: yield in replicated test of:	
	: 6 ft.	: 15 ft.	: 15 ft.	::	:
Yield measure	: Plant Cane	: Plant Cane	: Stubble Cane	:: Plant Cane	: Stubble Cane
Tons cane per acre	: 0.689 **	: 0.614 **	: 0.728 **	:: 0.724 **	: 0.810 **
Sugar per acre	: 0.735 **	: 0.655 **	: 0.672 **	:: 0.794 **	: 0.763 **

** Significantly different from zero at 1% level of P.

Table 3. Correlation coefficients (r) between graded and sampled yields in clonal plots and weighed yield in replicated test ^{1/}.

	: r values					
	: 6 ft. Plant Cane	: 15 ft. Plant Cane	: 15 ft. Stubble Cane			
	: Graded	: Sampled	: Graded	: Sampled	: Graded	: Sampled
Yield Measure	: Yield	: Yield	: Yield	: Yield	: Yield	: Yield
Cane per acre	: 0.390 **	: 0.499 **	: 0.361 **	: 0.525 **	: 0.635 **	: 0.574 **
Sugar per acre	: 0.641 **	: 0.522 **	: 0.560 **	: 0.539 **	: 0.612 **	: 0.563 **

^{1/} Plant cane is correlated with plant cane and stubble cane with stubble cane.

** Significantly different from zero at 1% level of P.

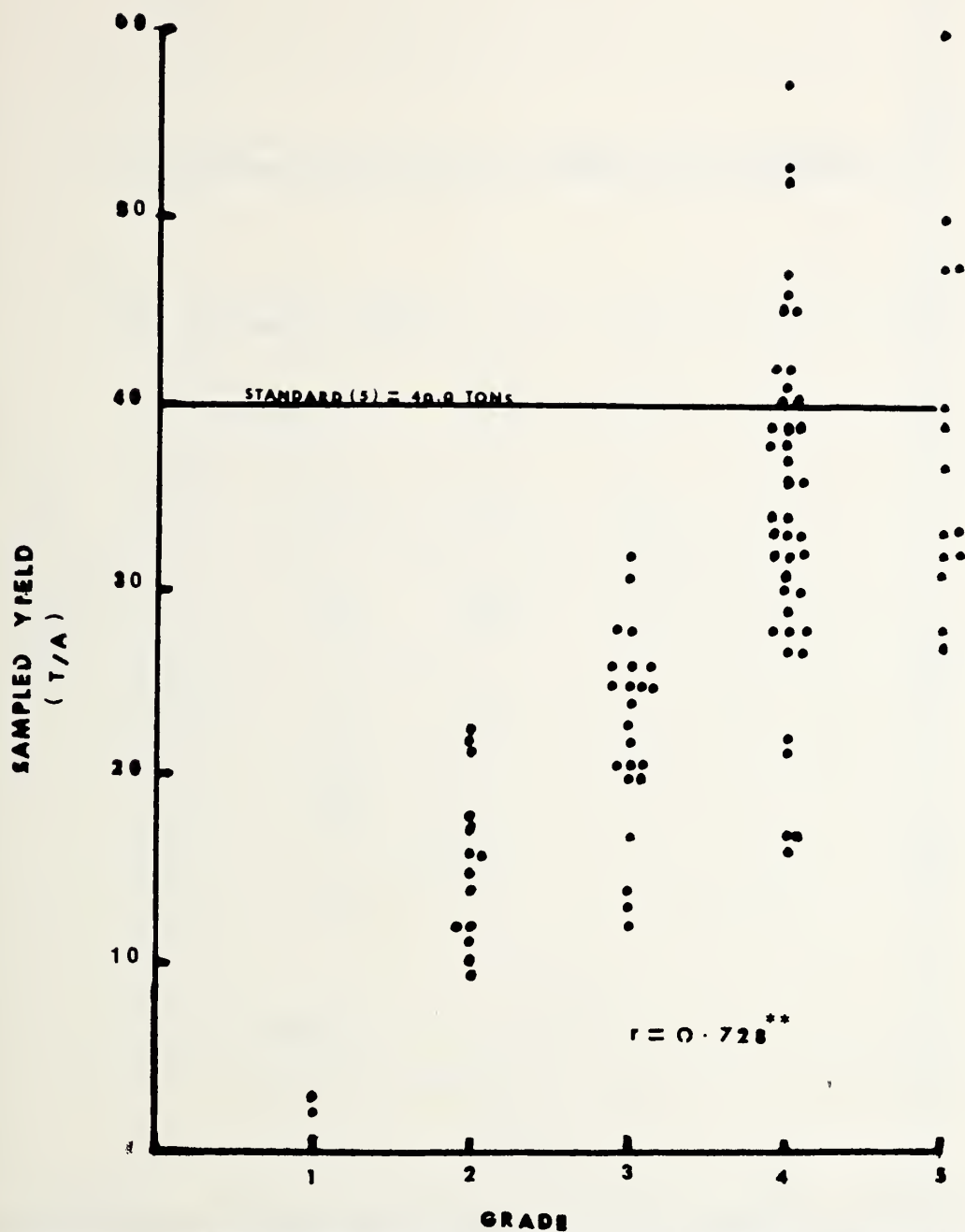


Figure 1. Scatter diagram giving distribution according to grade and sampled yield (T/A) of the 95 experimental clones in 15 ft stubble clonal plots.

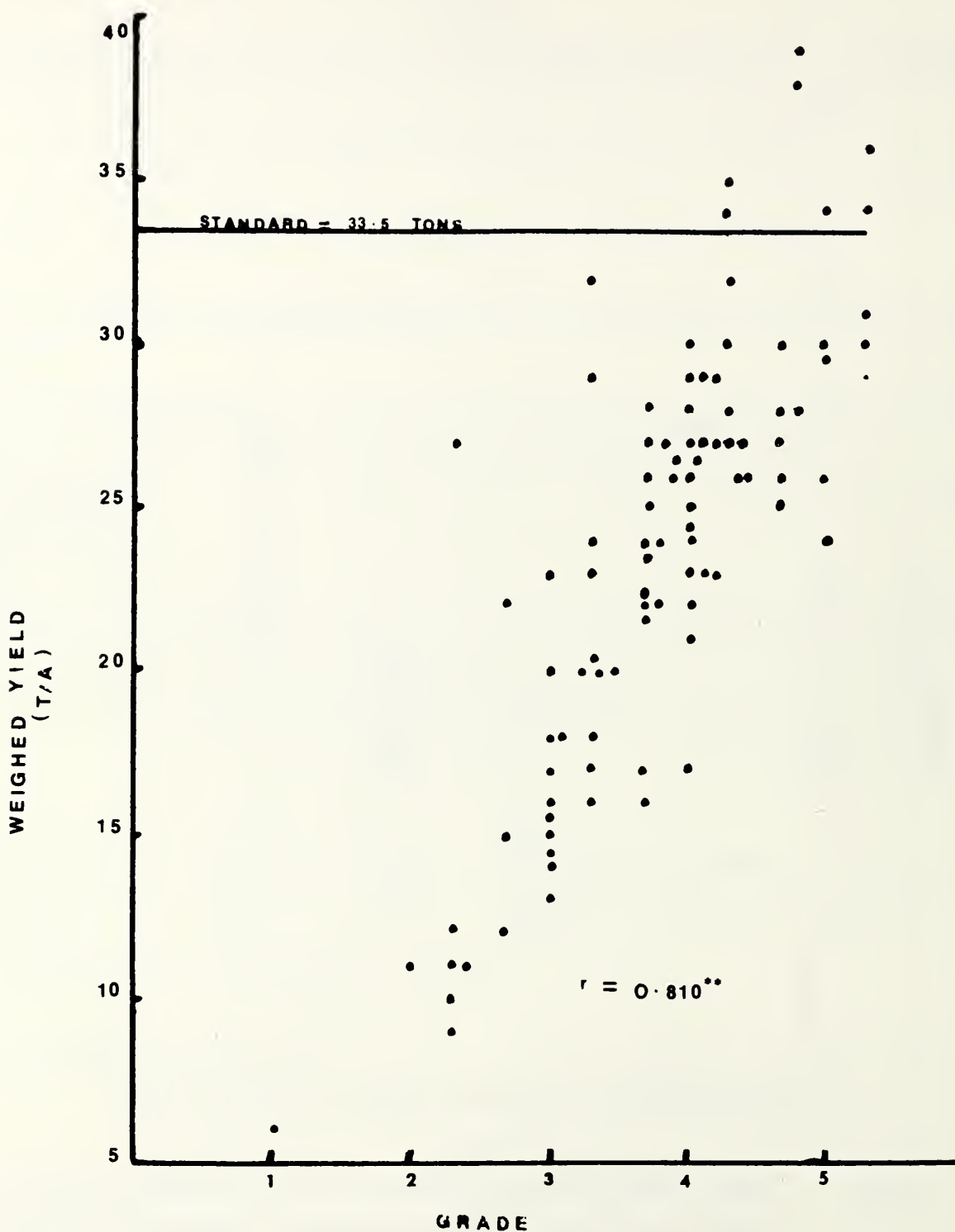


Figure 2. Scatter diagram giving distribution according to grade and weighed yield (T/A) of the 95 experimental clones in stubble replicated test.

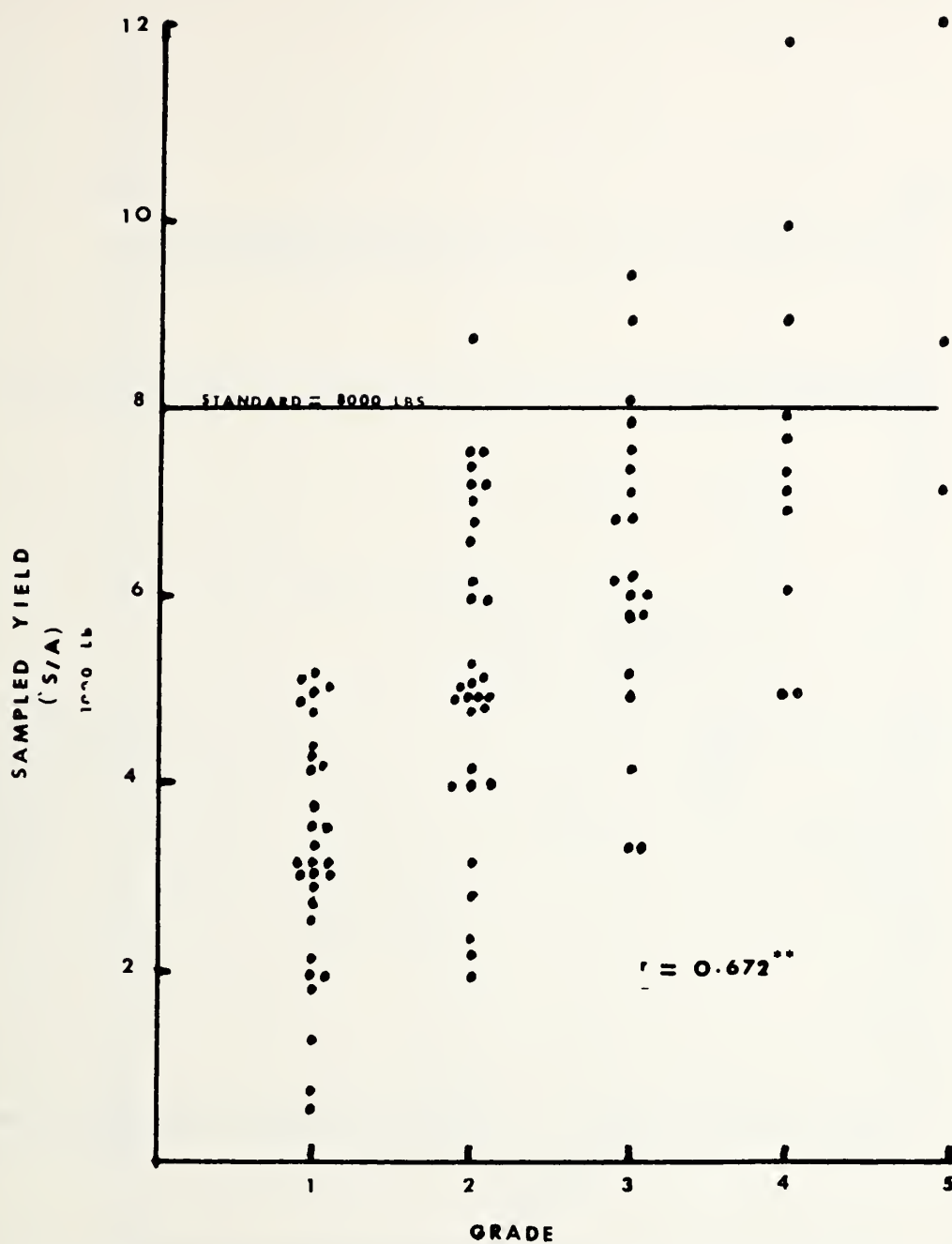


Figure 3. Scatter diagram giving distribution according to grade and sampled yield (S/A) of the 95 experimental clones in 15 ft stubble clonal plots.

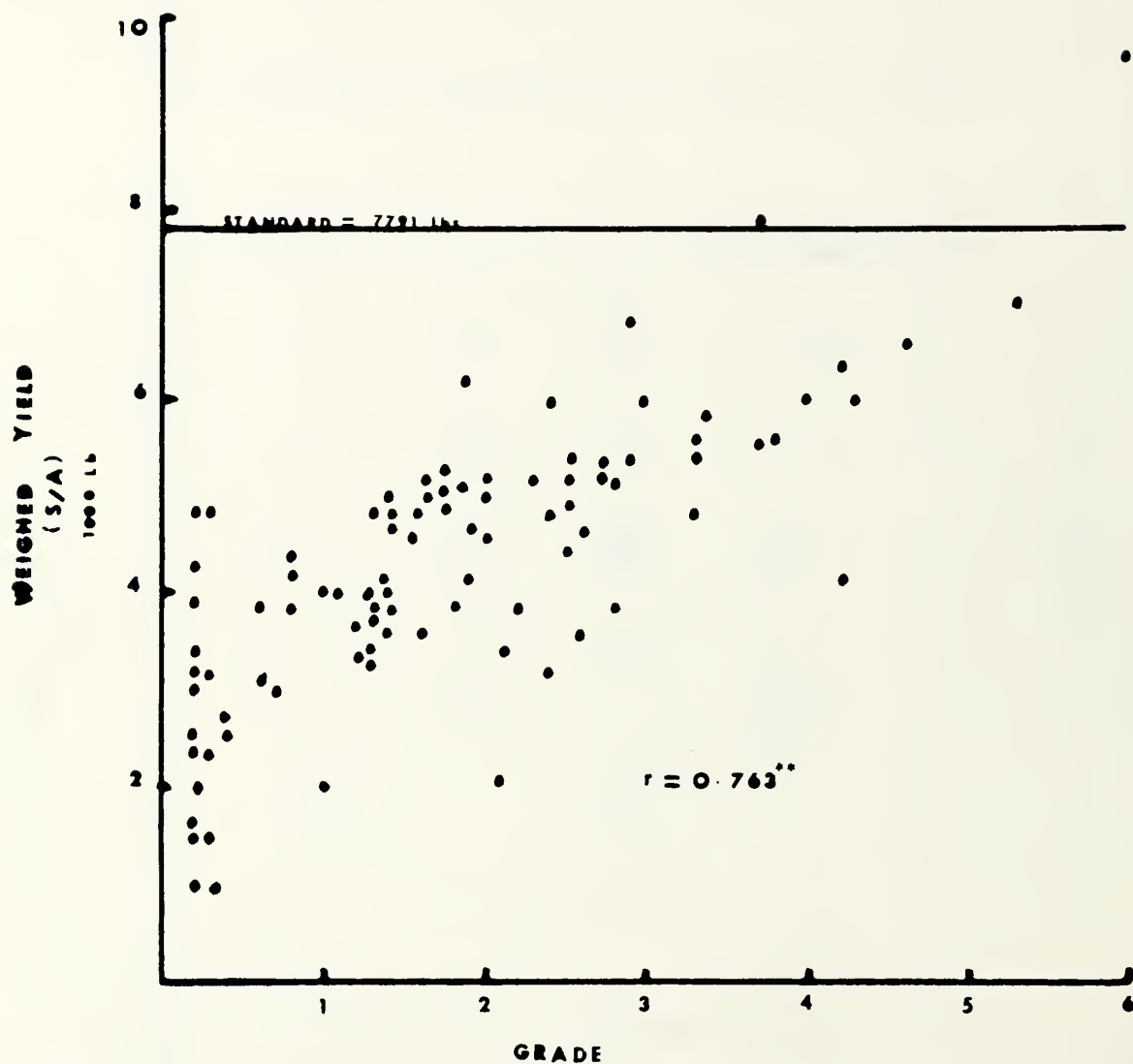


Figure 4. Scatter diagram giving distribution according to grade and weighed yield (S/A) of the 95 experimental clones in stubble replicated test.

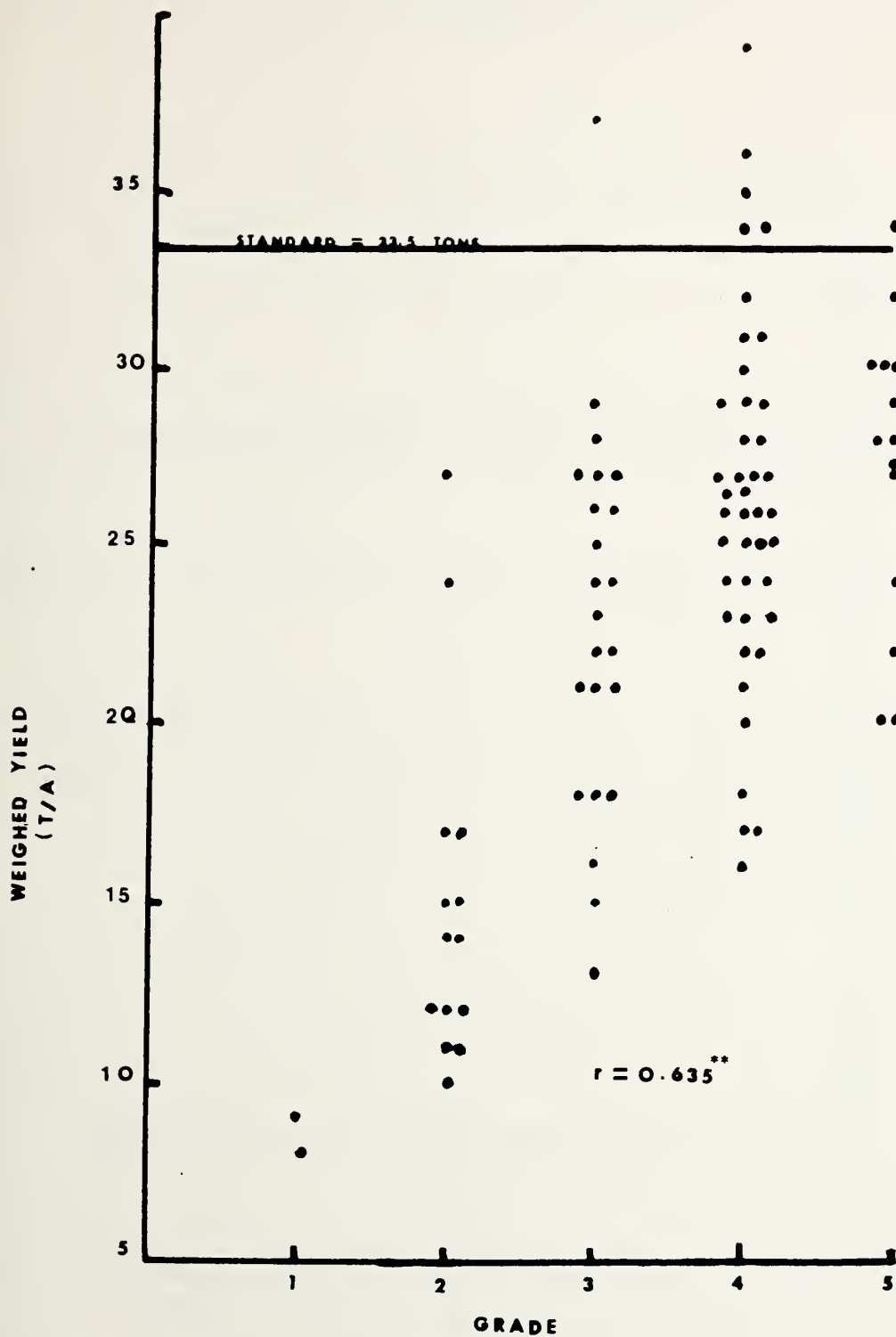


Figure 5. Scatter diagram giving distribution according to grade in 15 ft stubble clonal plots and weighed yield (T/A) in stubble replicated test.

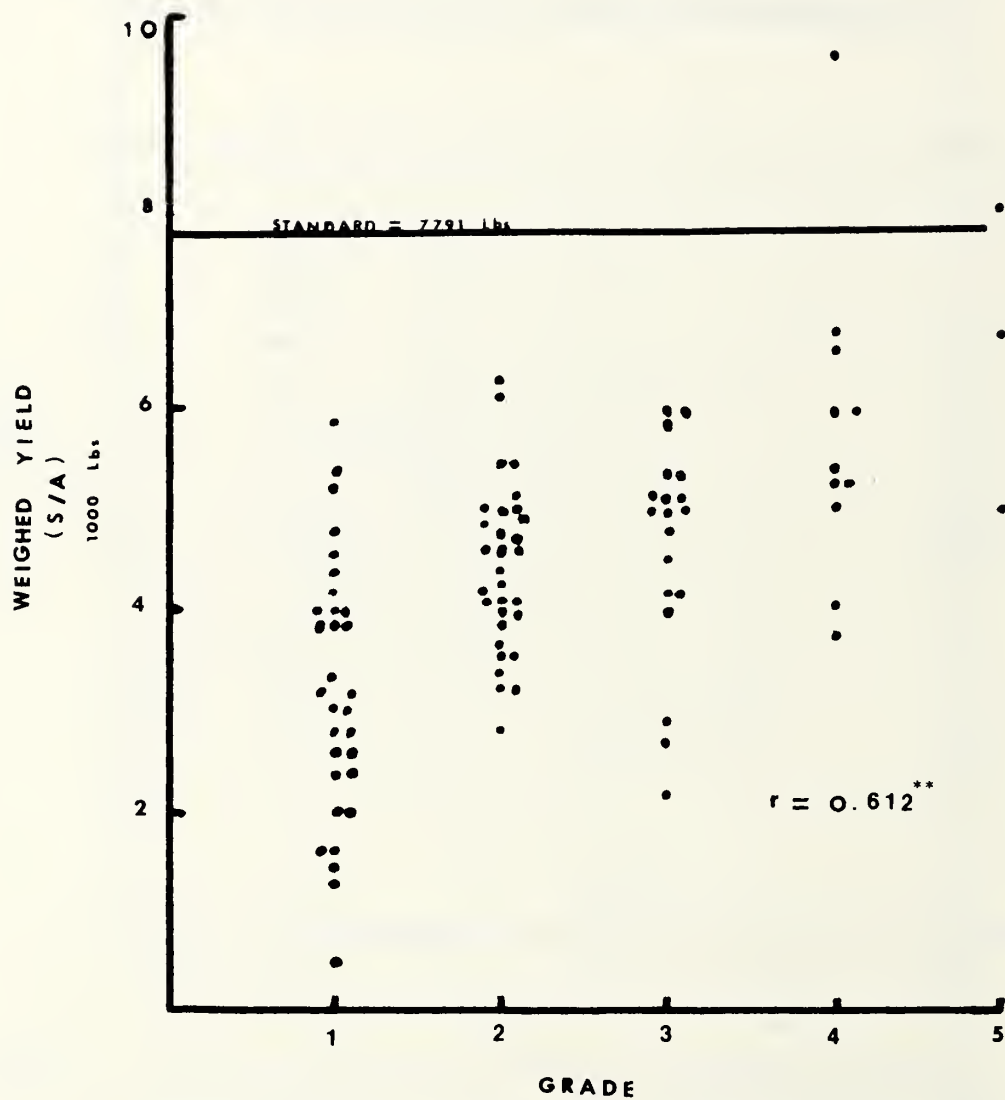


Figure 6. Scatter diagram giving distribution according to grade in 15 ft stubble clonal plots and weighed yield (S/A) in stubble replicated test.

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ABSTRACT

Commercial sugarcane varieties grown in Louisiana were bred on a narrow genetic base with a few clones of 3 basic *Saccharum* species (*S. officinarum*, *S. spontaneum*, *S. sinense*) hybridized by breeders in Java and India over 50 years ago. Not until 1936 did USDA breeders introduce genes from a new source, *S. robustum* variety 28 NG 251, which entered into the pedigrees of CP 55-30 and CP 50-28, varieties grown in Louisiana and Florida, respectively.

Varieties of acceptable quality are still being released from the recurrent breeding programs but the narrow genetic base may restrict future advances.

USDA breeders began a revitalization and expansion of breeding research in 1964. Its purpose was to identify and evaluate superior new germplasm to broaden the genetic base and breed for higher-yielding sugarcane with greater inherent resistance to disease, pests and adverse weather conditions.

Superior germ plasm from new sources, including many clones of the "wild" *S. spontaneum* species, was identified and used in the breeding program. New backcross (BC₂) lines are yielding clones which approach or exceed commercial varieties in stalk population, stalk weight, sugar content, and disease resistance.

While attempting to obtain maximum benefits from the traditional, but inbred lines, we are vigorously exploring the heterogeneous breeding potential of new germ plasm. Genetic diversity is the essence of a well-balanced sugarcane breeding program, and it is necessary to continued improvement.

INTRODUCTION

Since its inception the subtropical sugarcane breeding program of the USDA has relied on established breeding lines in developing varieties. A review of the genealogies of CP (Canal Point, Florida) varieties (23) shows that these lines were bred from a few clones of 3 basic *Saccharum* species (*S. officinarum*, *S. spontaneum*, *S. sinense*) hybridized by breeders in Java and India between 1890 and 1915. The POJ (Proefstation Oost Java) and Co. (Coimbatore) canes from India, which saved the Louisiana industry from ruin in the late 1920's (9, 21), also served as parents for the development of the better-adapted varieties now grown. Pedigrees of 30 Canal Point varieties released for commercial culture between 1930 and 1967 show that Black Cheribon was a basic parent in all varieties. Chunnee was a parent in all varieties except CP 36-13. Ashy Mauritius, Bandjermasin Hitam, *S. spontaneum* Coimbatore and a *S. spontaneum* hybrid, Kassoer, were initial parents in 15 or more varieties. If new genes from diversified sources are not added to broaden the narrow genetic base on which our conventional breeding program depends, future progress may be impeded.

Breeders attempted to develop cold-tolerant subtropical sugarcane by crossing Turkestan wild cane with Otaheite and POJ 2725 with no significant results in the late 1930's (3). The use of tropical canes as recurrent parents probably accounted for the rapid loss of cold tolerance needed in the subtropical environment. Now, with new techniques for determining cold tolerance in sugarcane (19, 20), and a wider range of recognized cold-tolerant germ plasm (12), we are again engaged in the development of cold-tolerant breeding lines.

There are definite signs of inbreeding depression and the exhaustion of genetic variability in breeding with the conventional lines in some subtropical programs (15). Sugarcane breeders in other parts of the world have had similar experiences. They also believe that this decline in the rate of varietal improvement is due to the exhaustion of genetic variability through selection in too few established breeding lines resting on a restricted genetic base (1, 5, 17, 18). Advances in yield have been made by breeding new varieties with increased sugar content, but we have not released a commercial cane for Louisiana that significantly outyields CP 44-101 in tonnage after 25 years of concerted effort (13), nor have we released a new variety equal to CP 52-68 in erectness.

Mosaic has spread throughout the major sugarcane varieties grown in Louisiana, and, in fact, has reached epidemic proportions. Reoccurrence of this disease is more common in subtropical than in tropical areas because of peculiar interactions between virus, vector and plant (2). The reappearance of mosaic stimulated greater effort to discover new sources of resistant germ plasm. Simultaneously, a quest for superior new gene sources to improve other essential varietal characteristics was begun (7).

The long-range objective of the basic breeding program is to produce higher-yielding sugarcanes with greater genetic resistance to disease, pests and adverse environmental conditions (15). By hybridization and rigid selection pressure we are combining the desirable features of the superior new germ plasm with those of the best interspecific hybrids bred from conventional lines. We are particularly interested in the new germ plasm as a source of higher cane tonnage, more stubble crops, erectness and adaptation to mechanical harvesting, higher levels of resistance to sugarcane mosaic, greater cold tolerance and more resistance to the sugarcane borer.

The sugarcane breeding program for Louisiana is a cooperative endeavor involving the U.S. Department of Agriculture, the Louisiana Agricultural Experiment Station, and the American Sugarcane League of the U.S.A., Inc.

BREEDING MATERIAL AND METHODS

This section and the Results and Discussion section are in parallel arrangement. Screening for mosaic resistance in the different classes of breeding material was essentially the standard procedure (6), modified where necessary (8, 10, 11), to increase selection pressure. New evaluation techniques for desired agronomic characteristics and cold tolerance were applied to improve efficiency in the identification of superior breeding material (12, 13).

- I. Saccharum spontaneum. This "wild" species is recognized as the primary source of genetic factors for mosaic resistance. Consequently, 262 clones of S. spontaneum were screened for mosaic in the greenhouse at Houma. S. spontaneum Coimbatore and Kassoer, the original basic sources of mosaic resistance, were used as control varieties in the tests. Commercial control varieties used were CP 47-193 (resistant), CP 48-103 (moderately resistant), and CP 52-68 (susceptible).

Single-eye cuttings of each clone were sprouted in an incubator before being transplanted to 3-inch peat pots. When the plants were about 6 inches tall they were inoculated with a mixture of mosaic strains by air-brush at 150 pounds pressure per square inch. The number of plants inoculated in the tests varied from 20 to 54 per clone. After 2 weeks all plants in the test were reinoculated to increase selection pressure. Clones that escaped infection in initial tests were repeatedly reinoculated and the most resistant clones were tested up to 6 times.

The inoculum used in all of the tests with S. spontaneum, and in other tests of similar nature, was a mixture of mosaic strains A, B, D, H, and I.

Thirty-two of the most mosaic resistant S. spontaneum clones were tested to ascertain their value as parents in breeding for important agronomic characteristics and cold tolerance. The test was conducted over a 2-year period. Both wild and commercial clones of known breeding behavior were used as controls. Two plants of each of the 36 clones in the test were grown individually in 15-gallon ash cans, outdoors. Field tests were impractical because of excessive rhizome production in some of these wild sugarcanes. Since some clones might become weed pests, we grew the plants in cans and removed seed heads before maturity to prevent spread of seedlings.

Stalk counts per can for each clone were made when the stalks reached maturity. Pith content, expressed as pith diameter percent stalk diameter was determined by cutting across the middle internodes of 6 random stalks from each can. Brix was determined by a hand refractometer, and by using juice from the middle internodes of 5 random stalks from each can. Cold resistance ratings for dead leaf tissue, dead terminal buds, and stalk damage were based on maximum cold damage after consecutive freezes in the winters of 1967-68 and 1968-69. Low temperatures of 24° F and 25° F for up to 5 hours duration were recorded during the winter of 1967-68. In 1968-69 we recorded lows of 25° F, 26° F, and 28° F with a maximum of 11 hours duration on January 5, 1969.

- II. Other Saccharum species and related genera. While emphasizing the use of elite S. spontaneum clones in developing improved breeding lines for Louisiana, we are also using unexplored breeding material of S. robustum, S. officinarum and S. sinense species in hybrid combination with conventional clones of good breeding potential. With new S. robustum clones we hope to broaden the genetic base to breed for greater vigor, larger stalk diameter, erectness, trash reduction, and general improvement in agronomic type. We are continuing the use of different clones of the "noble" S. officinarum species, as these canes are a source of genetic factors to breed for low fibre, juice quality and large stalk diameter. S. sinense is a recognized source of cold tolerance. New lines involving interspecific hybrids and various Saccharum species are intercrossed at different breeding levels, to increase in the progenies the desired characteristics of both the recurrent and non-recurrent (exotic) parents. Intergeneric crosses between Saccharum and related genera are being evaluated to determine if such lines offer breeding potential beyond the range of the genus Saccharum. Six genera - Erianthus, Miscanthidium, Miscanthus, Narenga, Sclerostachya, and Sorghum have been successfully hybridized with Saccharum (17).

- III. Interspecific hybrids. The adapted interspecific hybrids used as recurrent parents are evaluated in the cooperative testing program of the U.S. Department of Agriculture, the

Louisiana Agricultural Experiment Station and the American Sugarcane League (4, 16, 22). Commercial varieties are still regularly released from the large recurrent selection program of breeding with the best interspecific hybrids at Canal Point, Florida (CP varieties) and Baton Rouge, Louisiana (L varieties). These varieties are the products of 40 years of rigid selection pressure under Louisiana conditions. Superior hybrids of commercial value or with good breeding potential are included in the programs as recurrent parents as soon as they are identified.

Some of the commercial varieties considered of primary importance as recurrent parents are CP 48-103 (early high sucrose), CP 52-68 (erectness, combining ability), CP 61-37 (high tonnage, cold tolerance), L 60-25 (early high sucrose), L 62-96 (early high sucrose, erectness, large diameter stalks), and Cl 47-83 (cold tolerance, high sucrose, low fibre). Unreleased varieties include CP 57-526 (cold tolerance), CP 61-39 (mosaic resistance, high sucrose), L 61-67 (very high sucrose), L 65-69 (high sucrose, mosaic resistance), CP 65-357 (erectness, high sucrose, cold resistance), and CP 66-491 (borer resistance).

- IV. India (P.L. 480) progenies. Approximately 40,000 seedlings from crosses made at Coimbatore, India, between Canal Point interspecific hybrids and S. spontaneum clones were screened for susceptibility to strains of sugarcane mosaic prevalent in Louisiana in the quarantine greenhouse at Beltsville, Maryland in 1965-66 (7, 14). Cuttings of 921 clones were sent to Houma for evaluation.

The clones were again rigidly screened for mosaic in the greenhouse at Houma. Twelve plants of each Indian-bred clone and of 5 commercial control varieties replicated throughout the test, were inoculated. Five weeks after inoculation, the mosaic reaction of all clones in the test was recorded and susceptible clones were discarded. Those which did not take mosaic were planted in field nurseries where selections were made between 1966 and 1970 for agronomic characteristics, disease resistance, and borer resistance.

- V. Canal Point progenies. Recommendations for crosses desired for testing in Louisiana are submitted to the sugarcane breeders at Canal Point, Florida, a year before each crossing season. True (sexual) seed are then produced at Canal Point and sent to Houma for testing.

As soon as the "fuzz" containing the seed is received at Houma, germination tests are made and the number of viable seed per cross is estimated. These germination tests are used as indicators for sowing the fuzz properly. The seedlings are germinated at the rate of 300-500 per metal flat (15" x 21") in steam sterilized planting mixture composed of 70 parts of field soil, 10 parts sand, and 20 parts milled sphagnum moss. The temperature in the seedling greenhouse is maintained at about 85° F.

Screening for mosaic begins when the seedlings are 3 weeks old. The seedlings are inoculated 2-3 times at intervals of 7-10 days while in flats. Diseased seedlings are rogued from the flats as mosaic symptoms appear. Three weeks after the last inoculation in flats the symptomless seedlings are transplanted singly to 1 3/4-inch peat pots. When well-established in pots the seedlings are inoculated 2 more times. Seedlings showing the slightest symptoms of the disease are discarded. In late April the apparently mosaic-free seedlings are transplanted singly to the field.

Special attention is paid to cultivation, weed control, fertilization and pest control in the young seedlings. No selection is practiced in plant cane and the crop is mechanically harvested in December. Natural stresses of the Louisiana environment eliminate the weakest clones in the over-wintering crop. In the spring, mosaic-infected survivors are rogued from the nurseries by cutting and spraying the freshly cut stubble with herbicides. In the mature stubble crop a careful selection is made for erectness, tillering, stalk diameter, internal stalk characteristics, freedom from disease, tolerance to the sugarcane borer, overall hybrid vigor and goodness of type. Commercial control varieties planted throughout the nurseries are used as guidelines for selection. After this subjective evaluation, the selected clones are brought to the headlands and brixed by means of the hand refractometer. The clones in each progeny are separated into classes from the lowest brix to the highest. Minimum standards are set for each cross, so that some clones are selected even in early generation, low sucrose crosses. It is not demanded that early generation selections meet commercial standards, but rather that they are the best found in each new line. Following this initial selection the new clones are given US (breeding) designations and numbered according to breeding line. Evaluation of selected clones for disease and borer resistance, agronomic characteristics and cold tolerance is continued in a series of line trials and replicated tests. Selected clones are returned to the crossing program for further use in breeding, or included in the testing system if they appear to have commercial possibilities.

RESULTS AND DISCUSSION

- I. Saccharum spontaneum. In a series of greenhouse tests at Houma, where 262 S. spontaneum clones were repeatedly screened for mosaic, 83 failed to show symptoms of the virus, whereas both the "wild" and commercial controls became infected. In the same tests 179 S. spontaneum clones took mosaic, and 43 in this group became 100 percent infected (11).

Agronomic and cold resistance studies on 32 selected mosaic-resistant S. spontaneum clones grown in can cultures revealed significant differences among the clones for stalk number, pithiness, brix and dead leaf tissue (12).

All of the wild clones were significantly higher in stalk number than the commercial control varieties CP 48-103 and CP 52-68. Okinawa No. 2, SES 114, SH 246, US 60-4-6, US 61-2-1 and US 61-4-1 were significantly better than S. spontaneum Coimbatore in number of stalks per stool.

Pith diameter varied from 0 in US 56-8-2, US 56-15-2, and US 56-15-8 to 75% of stalk diameter in SES 351. In S. spontaneum Coimbatore 20% pith was recorded; most of the wild clones did not differ significantly from the wild control.

Brix ranged from 4.6 in Mandalay to 14.5 in US 56-8-2. Coimbatore averaged 7.5 brix and was exceeded by 14 of the other S. spontaneum clones tested. CP 48-103 and CP 52-68 were significantly better in brix than the wild clones.

- II. Other Saccharum species and related genera. Since 1964 more than 5,500 seedlings, from new breeding lines involving S. robustum varieties and routine breeding lines, have been evaluated at Houma. Approximately 85% of these seedlings were eliminated because of mosaic susceptibility in the greenhouse. Many S. robustum progenies are deficient in stalk number, sucrose content and cold tolerance. Although the frequency of promising clones from S. robustum progenies is lower than for S. spontaneum progenies, a few show good stubbling ability combined with excellent type, mosaic resistance, and satisfactory sucrose in second generation backcrosses. Some of the best S. robustum and S. spontaneum lines selected at Houma were intercrossed in the fall of 1969. In the fall of 1971, over 3,000 seedlings from these intercrosses will be available for selection in the single-stool nurseries.

More than 3,000 seedlings from crosses between "noble" (S. officinarum) X CP varieties were recently grown at Houma. Seven were assigned CP numbers in 1965 and these ranged in sucrose content (line trials and pre-replicated nursery) from 97-105% of standard variety CP 52-68. Two of these noble derivatives, CP 65-398 and CP 65-399, were given the highest vigor ratings among forty 1965 CP canes replanted to replicated infield trials at Houma and Baton Rouge. However, both were eventually dropped from the testing program because of susceptibility to mosaic and weak stands in second stubble. The noble parents in these crosses were 28 NG 288 (striped) and SS 58-8. Progenies of S. officinarum X CP varieties are generally lacking in stubbling ability, erectness, disease resistance and early maturity. Probably the old noble genome, although once commercial in Louisiana, is now so far removed from the present commercial genome that backcrossing may be as necessary, to transmit new genes from it to commercially acceptable clones as from the wild species. Further backcrossing and/or intercrossing of these S. officinarum derivatives is anticipated.

Only limited results have been obtained at Houma in ascertaining the breeding potential of Saccharum in combination with other genera which hybridize with sugarcane. Over 7,300 seedlings from F₁ and BC₁ crosses, involving Saccharum in hybrid combination with Sclerostachya, Erianthus, and Miscanthus, were screened for mosaic and agronomic characteristics since 1965. Many specific clones of these genera have never been evaluated as parental material in Louisiana; but the breeding behavior of those we used tended to be inferior to CP varieties X S. spontaneum crosses. Of the 7,327 intergeneric seedlings screened for mosaic in the greenhouse, 6,752 (92%) became infected. Less than half this percentage infection occurred in over 37,000 seedlings of S. spontaneum lines involving similar varieties in the same tests. Agronomically, the few intergeneric seedlings screened in the field tended to lodge more frequently; they were pithy, lacking in juice, and usually low in sucrose.

- III. Interspecific hybrids. Locally adapted interspecific hybrids combined better with new germ plasm than hybrids from other breeding programs. In general, hybrids adapted to other areas do not possess the innate genetic potential required by the subtropical environment. Most imported hybrids are susceptible to the strains of mosaic prevalent in Louisiana; they are late-maturing and ratoon poorly. Crosses involving exotic germ plasm and adapted interspecific hybrids consistently outperformed similar crosses where unadapted recurrent parents were used. The overall beneficial effects of combining new germ plasm with the locally adapted interspecific hybrids is apparent in greenhouse, field and laboratory results at Houma. However, in breeding for traits such as low fibre or greater stalk diameter we occasionally use exceptional interspecific hybrids from other programs.
- IV. India P. L. 480 progenies. Thirty-two Indian-bred US (breeding) clones were sent to Canal Point in 1969 for inclusion in new crosses. These clones are superior to commercial control varieties in stalk number, erectness, and ratooning ability; however, they are inferior in sucrose, stalk diameter, and stalk weight. All 32, in a special nursery where we screened for resistance to the sugarcane borer, had fewer bored joints than N.Co. 310, the most borer-resistant commercial variety grown in Louisiana (unpublished data of Entomology Department). During the 1970-71 breeding season 19 backcrosses involving 13 of the new P. L. 480 clones were made.
- V. Canal Point progenies. Since 1964, over 194,000 seedlings from crosses including new gene sources have been screened for mosaic at Houma (Table 1). Completion of a new greenhouse

made it possible to screen over 68,000 seedlings for mosaic in the Spring of 1970; more than 28,000 mosaic-free seedlings were set to the field that Spring. Results of selection in new progenies indicate that the number and quality of US (breeding) clones are increasing in proportion to the effort expended. As the table shows, 1,638 new selections were given US numbers between 1964 and 1968. Most of the effort given to expansion of the seedling program was necessarily centered around the F₁ and first backcross generations (15). Since superior clones from early generation crosses have been identified, effort is shifting toward the breeding of second and third backcross lines. Also, intercrossing within or between new lines of diverse genetic backgrounds has already begun and progenies are being evaluated.

A study of 150 selections from BC₂ progenies of S. spontaneums US 56-15-8 and Passoeroean revealed that the desired characteristics of these wild parents are being transmitted to clones that are approaching, and in some cases exceeding, commercial standards for stalk population, stalk weight and brix (Table 2). These clones had a mean stalk population of 48 stalks per 6 X 12 ft. plot, which exceeded the stalk number of CP 61-37, a commercial standard for good stalk population and high cane tonnage. Individual clones ranged up to 90 stalks per plot of cane compared to an average of 40 for CP 61-37. The average stalk weight of the 150 clones was essentially equal to CP 61-37, but many clones were heavier than CP 61-37 and weighed up to 4 lbs. per stalk. The average brix of the clones was approximately equal to CP 52-68, a standard sucrose commercial variety and still the dominant cane in Louisiana. Seventeen clones were equal to or better in brix than CP 48-103, a high sucrose commercial standard. In the fall of 1971, some of these clones will be planted in replicated tests in the commercial breeding program. This basic program has already yielded 8 varieties that are in advanced agronomic trials at Houma.

CONCLUSIONS

Subtropical sugar-producing areas cannot rely indefinitely on the genetic resources of inbred lines resulting from one or two initial Saccharum nobilizations made in the tropics over 50 years ago.

The evaluation and use of new germ plasm is essential to continued sugarcane improvement in Louisiana, Florida and other Temperate Zone areas.

New S. spontaneum gene sources in hybrid combination with locally-adapted sugarcanes show special promise in developing improved subtropical varieties with higher levels of resistance to mosaic and insect pests, greater stalk populations and more cold tolerance.

The use of new clones of S. officinarum, S. robustum and S. sinense, must be continued to broaden the genetic base to breed for larger diameter stalks, better juice quality, and lower fiber content; for greater erectness and less trash; for additional cold tolerance, overall hybrid vigor, and other desired genetic traits.

Intergeneric hybridization between Saccharum and other genera must be given special consideration to determine if such lines offer breeding potential beyond the range of interspecific Saccharum crosses.

The challenge to significantly improve sugarcane in the subtropical environment is formidable but not insurmountable. Judicious use of the vast germ plasm resources of the World Collection of Sugarcanes should meet the challenge.

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TABLE 1. Summary of seedlings from Canal Point, Florida basic crosses grown and tested at Houma, Louisiana 1964-69.

Breeding	Seedlings tested	<u>Seedlings discarded</u>		Seedlings set	US (breeding)
Series	in greenhouse	Mosaic	Other	to field	assignments
<u>Year</u>	<u>Number</u>	<u>Percent</u>	<u>Percent</u>	<u>Number</u>	<u>Number</u>
1964	18,000	31.1	44.3	4,909	200
1965	15,000	55.5	24.6	3,170	225
1966	11,176	36.3	31.8	3,567	218
1967	51,115	52.8	25.0	12,354	719
1968	31,000	69.4	6.2	8,680	276
1969	68,491	58.7	0.0	28,275	<u>2/</u>
Total or Ave.	194,782	53.3	11.3	60,950	1,638 <u>3/</u>

1/ 2-5 inoculations with a mixture of mosaic strains A, B, D, H, and I; administered by air-blast technique.

2/ To be assigned US numbers in the fall of 1971.

3/ Number of US assignments through CP 1968 series.

TABLE 2. A comparison of principal yield components of 150 clones from BC₂ progeny of *S. spontaneums* US 56-15-8 and Passeroean with standard varieties.

	Stalk No. 1/	Stalk Wt. 1/	Brix 2/
No. clones better than control	140	48	12
No. clones equal to control	3	25	5
No. clones less than control	7	77	133

1/ Compared to CP 61-37 (high stalk population, high tonnage).

2/ Compared to CP 48-103 (early high sucrose).

COMPARISON OF ESTIMATED AND WEIGHED YIELDS IN
SUGARCANE VARIETY TRIALS; PRELIMINARY RESULTS

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ABSTRACT

Estimated yields, obtained by multiplying number of stalk times average stalk weight, were compared to weighed yields obtained with a tractor mounted hydraulic grab and scale. The two methods of obtaining yield were compared in 4 outfield variety tests during 1969 and 1970.

Estimated and actual yields were significantly correlated ($r = .69^*$, $.82^{**}$, $.86^*$, and $.92^{**}$) in all experiments. The ranking of varieties for tons of cane per acre was very similar by both methods, but the coefficients of variation were lower when plots were weighed (4.83 vs 10.47%, 6.58 vs 11.23%, 6.98 vs 9.66% and 9.50 vs 14.16% in the four experiments).

Comparison of weighed and estimated yields could be of value in determining yield potential of varieties when extensive lodging occurs after a hurricane, or heavy rains and wind in excess of 25 mph. Under such conditions heavy ground losses occur when plots are cut by mechanical harvesters.

INTRODUCTION

Traditionally, sugarcane variety yield data has been obtained at the outfield by weighing whole plots. This study compares estimated yields to weighed yields in 4 experiments.

Hogarth and Skinner (5) investigated several methods of obtaining estimated yields from plots. They found the most practical method of obtaining estimated yields was to obtain average stalk weight by hand cutting a 45-60 stalk sample from the middle of the plot. The average stalk weight was then multiplied by the number of mature stalks in the plot.

Hebert (4) found estimated yields agreed closely with yields obtained by hand cutting and weighing small single row plots. He indicated accurate plot weights were always preferred over estimated yields, but that estimated yields were an acceptable substitute when no other means of obtaining yields was possible.

In the current outfield testing program, both commercial and experimental varieties are evaluated on 14 cooperating plantations, which are representative of the sugarcane-producing area of Louisiana. The outfield experiments, conducted on a cooperative basis with the Louisiana Agricultural Experiment Station, the American Sugar Cane League and the U. S. Department of Agriculture, are the final tests before varieties are released for commercial plantings.

Experimental varieties are tested in plant cane, first stubble and second stubble crops in the outfield before they are considered for release. Most of the outfield plots were cut by hand until 1967. Hand and machine cutting of outfield plots were compared during 1966; the coefficient of variation varied little between the two methods of harvest (1). Since 1967 all plots have been cut by plantation owned mechanical harvesters.

Two of the important determinations which must be made on the new varieties during the 3 year period of outfield testing are yield potential and adaptability to mechanical harvesting. When erect varieties are harvested these two determinations are made by weighing whole plots (1), and by observing stalk breakage during the cutting operation.

Extensive lodging in variety plots may reduce the reliability of machine harvested tests for estimating yield potential. Recumbent stalks may be missed by the harvester. Stalk breakage results in additional loss in varieties which are excessively brittle (3) during the post-lodging period. Estimated yields could more accurately assess the potential of these varieties than weighed yields. A combination of estimated and weighed yields could be used to indicate yield potential and harvesting behavior of varieties.

MATERIALS AND METHODS

Estimated and weighed yields were obtained in plant cane outfield variety tests. The tests contained 18 varieties in 1969 and 13 in 1970. The varieties were planted in a randomized complete block design with 4 replications. The 3 row plots covered an area 18 ft wide and 32 ft long with a 4 ft

pathway (1/67 acre). The plots were planted in September with hand-cut, full length stalks of sugarcane. Two stalks were placed in the open furrow and the top immature part of the stalks were overlapped approximately 10% with the bottom of two other stalks. This lapping was continued until the desired plot length was achieved.

The estimated yields per plot were obtained by multiplying the number of millable stalks per plot times the average stalk weight per plot. Plot yield in pounds was converted to tons of cane per acre. Millable stalk counts can be made from September through November since there is little change in the number of millable stalks after August. Millable stalk counts were made in September for 2 experiments, in October for one experiment and in November for the last experiment. The November counts were made at the time the test was harvested. Average stalk weight was obtained by hand-cleaning and weighing a 20-stalk sample which was later used for sucrose analysis.

The weighed yields were obtained by cutting the 3 row plots with plantation owned mechanical harvesters. Cane missed by the harvester was recovered and placed on the heap row. The unburned cane was piled and weighed with a tractor mounted hydraulic grab and scale immediately after cutting (2). The cane trash, (dry and green leaves) which varied from 10-20% of the plot weight, was determined by hand-cleaning a 200-pound sample. The weight of trash was deducted from the gross-plot weight before calculating yield of cane per acre.

RESULTS

The coefficients of variation for tons of cane per acre for both methods of harvest are presented in Table 1. The values for the weighed yields were lower than those for estimated yields in all 4 experiments.

The correlation coefficients (r) of .82**, .69*, .86* and .92** were obtained for estimated x weighed yields in the 4 experiments. These high r values indicate a close association between estimated and weighed yields.

Differences in tons of cane per acre between the 2 methods were noted in the Georgia plant cane experiment harvested during 1970 (Table 2). Estimated yields of varieties CP 61-37, L 60-25 and CP 65-350 were higher than weighed yields by 2.49, 3.84 and 4.70 tons per acre, respectively. All varieties with the exception of CP 65-350 maintained the same relative position according to the Duncan multiple range test regardless of the harvesting method. The difference between estimated and weighed yields was less for varieties CP 52-68 and L 62-96 than for other varieties in the Georgia experiment.

DISCUSSION

The estimated sugarcane yields from machine cut plots were compared to the standard method of harvest in 4 outfield variety tests conducted on cooperating plantations.

The coefficient of variation ranged from 4.83% to 9.50% for the weighed yields; this variation was not excessive in spite of extensive lodging in the Georgia and Bon Secour experiments during 1970. The higher coefficient of variation which ranged from 9.66% to 14.16% for estimated yields may be due to sampling error in average stalk weight or millable stalk counts. The high coefficient of variation may be lowered by obtaining a representative 20 stalk sample from machine cut plots. Inaccurate millable stalk counts contribute to high coefficient of variation; inaccurate counts occur because some varieties produce stalks which are borderline in size and in height and may not be gathered by the mechanical harvesters. Accurate stalk weights and millable stalk counts must be obtained in order to estimate yields accurately. It is possible that hand-cut samples may be more reliable than machine-cut samples; but due to labor shortage and difficulty in cutting samples in lodged experiments this may not be feasible.

These results agree with results found by Hogarth and Skinner (5) who obtained correlation coefficients in the area of .90 between estimated and weighed hand-cut plot yields by using their method of estimating yields in several experiments. They found a method of estimating yields necessary because manual cutting was being rapidly replaced by mechanical harvesters. They could not obtain yields from experiments cut by the widely used chopper harvesters, which cut and load in one operation. They reported no serious difficulties in erect experiments, but considered the method impracticable in severely lodged sugarcane. This may have been because it is very difficult to properly hand-cut samples in badly lodged sugarcane.

Hebert obtained correlation coefficients (r) ranging from .66 to .90 when he compared estimated to weighed yields in several experiments. The need of a method of obtaining estimated yields was intensified because of the mechanical difficulty in weighing small single row plots.

One of the experiments where estimated and weighed yields differed was at Georgia (Table 2). Three lodged varieties ranked higher when yields were estimated than when yields were determined by weighing. A difference of 4.7 tons per acre between estimated and weighed yields of CP 65-350 indicated that losses would have been high if this severely lodged variety were machine harvested. Estimated and weighed yields differed only .78 tons for the erect variety CP 52-68. A difference of .94 tons between estimated and weighed yields was obtained for the tall fairly erect variety L 62-96. The mechanical harvesters did a better job of gathering and topping the erect varieties resulting in little ground

loss. Mechanical harvesting of lodged varieties causes high ground loss because of extensive breakage. These losses affected results even though the plots were hand scrapped before weighing.

Estimated yields are of value in variety yield experiments to predict the harvesting behavior of experimental varieties, and to obtain more accurate yields of badly lodged varieties. The accuracy of estimated yields can be improved by obtaining accurate counts of millable stalks, and by obtaining accurate estimates of average stalk weights with larger machine or hand cut samples.

Some variety experiments lodge late in the growing season when heavy rains are followed by moderate winds (in excess of 25 mph). Under these conditions, weighed yields from such experiments could be misleading. However, it is very difficult to obtain accurate millable stalk counts for estimated yields in lodged sugarcane. While harvesting the Georgia experiment accurate stalk counts were made on each row as it was exposed when the harvester cut adjacent rows. Additional comparisons of estimated, and weighed yields are needed to determine the reliability of this method for evaluating yield potential of new varieties.

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TABLE 1. Estimated x weighed yields of 4 outfield experiments.

TABLE 1. Estimated and weighed yields of 7 Southern experiments						
	: Coefficient of variation (%) :			Correlation		
Location	: Estimated yields :		Weighed yields :	coefficient (r)		
Plant Cane 1969						
Georgia	:	10.47	:	4.83	:	.82 ** <u>1/</u>
Bon Secour	:	11.23	:	6.58	:	.69 *
Plant Cane 1970						
Georgia	:	9.66	:	6.98	:	.86 *
Bon Secour	:	14.16	:	9.50	:	.92 **

1/ * Significant at the 5% level of probability.

** Significant at the 1% level of probability.

TABLE 2. Estimated and weighed yield in tons of cane per acre and rank of varieties at Georgia Plantation during 1970.

						Difference	
Variety	: Weighed 1/ :	Rank	: Estimated :	Rank	: (W-E)		
CP 61-37	: 33.93 a :	1	: 36.42 a :	1	: - 2.49		
L 62-96	: 32.33 a :	2	: 33.27 ab :	2	: - .94		
L 65-69 2/	: 27.96 b :	3	: 29.71 bc :	5	: - 1.75		
L 60-25	: 26.83 b :	4	: 30.67 bc :	3	: - 3.84		
CP 52-68	: 26.74 b :	5	: 25.96 c :	7	: + .78		
CP 48-103	: 25.58 b :	6	: 26.95 c :	6	: - 1.37		
CP 65-350 2/	: 25.51 b :	7	: 30.22 bc :	4	: - 4.70		

1/ Means followed by the same letter are not significantly different at the 5% level of probability according to the Duncan multiple range test.

2/ Experimental varieties.

NEW SUGARCANE CLONES WITH SUPERIOR COLD TOLERANCE

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ABSTRACT

Early attempts to introduce cold tolerance into tropical sugarcane varieties resulted in successful crosses but rapid loss of cold tolerance. Attempts to obtain cold tolerant varieties through routine screening of subtropical seedlings resulted in only a few commercially acceptable clones. The recent introduction of new genetic lines has apparently increased the frequency and quality of cold tolerant varieties.

The existence of varietal differences in cold tolerance was demonstrated as early as 1926 in Cuba (8) and in Louisiana in 1927 (11). Active efforts to breed for cold tolerance were not begun until 1935 when E. W. Brandes received a packet of seed of Saccharum spontaneum, collected on the Amu Dar'ya, a tributary of the Aral sea, in Uzbek, S.S.R. (2). The plant was widely distributed along the banks of the river as far north as 40°N latitude, or the approximate latitude of New York City. The seeds were not viable, so Dr. Brandes secured a second shipment. These seeds germinated and two of the three collections proved to be S. spontaneum. The plants were started in April, and flowered in July, 1936. They remained in the field the following winter and some stalks had viable buds after 14 days with minimum temperatures below 20°F and one day with a minimum of 14.5°F.

The introduction by hybridization of cold tolerance into subtropical sugarcane was blocked by the early flowering of the Uzbek form. The S. spontaneum from Uzbek flowered during the long days of summer while the commercial canes flower during the shorter winter days. In the summer of 1937, Dr. Brandes, a proven innovator, flew whole flowering plants of S. spontaneum to Colombia where winter day-lengths made tassels abundant in commercial canes. The initial attempt to cross S. spontaneum with a commercial variety failed, and a second attempt was made in 1938. This time only pollen was flown from Washington to Colombia. As insurance, whole flowering plants were trucked to New York, shipped to a Colombian seaport and packed over the Andes to the experiment station at Palmira-Valle, Colombia, where several varieties of tropical canes were in flower. Both methods of shipment were successful; 15,000 seedlings were obtained from seed flown back to Washington. These were transplanted to the field; a few plants that may have been selfs did not survive the first freeze. In 1938, a backcross was made to the commercial parent in Colombia and the seed flown to Washington. Further crosses were made in 1939 to Otaheite (Bourbon) and to POJ 2725 (3). During the winter of 1939 the original male parent (S. spontaneum from Uzbek) survived temperatures of -2°F. Although the germ plasm of this spectacular cold-tolerant form had been successfully incorporated into a hybrid with a tropical parent, the cold tolerant character proved elusive. Repeated crossing to tropical varieties produced varieties approaching commercial type but without the ability to tolerate cold. Varieties with 1/4 or 1/8th of Uzbek parentage could tolerate temperatures no lower than 25-26°F. Successful attempts were made to control flowering in Canal Point, Florida, by photoperiod control. Interspecific hybrids could be made to flower at the time of flowering of the BC₂ progeny, thus eliminating the need for interhemispherical shipment (5). No new combinations of S. spontaneum with these subtropical interspecific hybrids were achieved and the program was abandoned.

Subsequent attempts to find cold tolerance were centered on the screening of progenies of crosses between interspecific hybrids in the standard breeding program. This program was centered on the production of varieties for Louisiana and Florida. Selections were made for cold tolerance in commercial type hybrids in young cane (1) and in mill cane (6, 9, 10). In the 45 years that cold-tolerant varieties have been sought in Louisiana, few have appeared. Only two varieties (NCo 310 and CP 61-37) with superior cold tolerance have been released to growers. Other varieties with superior cold tolerance have been identified (CP 65-357, CP 57-526, CP 46-115 and CP 43-33) but have not been released for production. The frequency of superior cold tolerance in the progeny of crosses designed for commercial varieties is very low. This is indicated by comparing the number of superior varieties (six) to the number of new varieties available every year (60,000-80,000). While differences in cold tolerance can be readily detected in the field (6, 10) or in the laboratory (9), these differences usually only separate the moderately resistant from the susceptible varieties.

More recent efforts to incorporate new germ plasm into the variety development program have included hybridization involving numerous crosses among S. spontaneum, S. robustum, S. officinarum and interspecific hybrids. Some intergeneric crosses have been included (7). Many of the parent clones have been evaluated for cold tolerance and some have shown promise. Progenies of crosses involving species and backcrosses are evaluated in the field. Crosses between varieties having superior cold tolerance have been made; clones with superior cold tolerance originating from these crosses have not yet been identified.

Following a freeze in November, 1969 (27°F), we examined approximately 14 acres of plant cane seedlings for cold-tolerant selections. None was found in the 10 acres of seedlings in the commercial program, but many were noted in almost 4 acres of seedlings and clones of F₁, BC₁ and BC₂ progenies of crosses involving interspecific and intergeneric crosses (7). Altogether, 292 clones were selected which showed some evidence of cold tolerance. The selections were cut and planted late that November. The planting was made in the coldest part of the Experiment Station at Houma, La., with the cold-tolerant commercial varieties, NCo 310 and CP 61-37, as checks. Spring stands were excellent, the late planting and frosted seed cane, notwithstanding. The plots were fertilized and cultivated in the standard manner, and a good crop was produced. A light freeze on Nov. 17, 1970, discolored the leaves of many adjacent commercial varieties but left the cold-tolerant varieties relatively unaffected. More severe freezes on Nov. 24th and 25th (26°F) caused complete bleaching of leaves and the death of all terminal buds, some lateral buds, and 2-8 inches of stalk tissue in all commercial varieties. We allowed freeze damage symptoms to become well developed, and, on Dec. 9, 1970, we screened the cold-tolerant selections. Clones were accepted that had a minimum of 25% green in the total leaf area, no stalk damage, and no lateral bud damage.

Of the original 292 selections, 60 clones were reselected as having cold tolerance as good or better than NCo 310 or CP 61-37. Ten of these 60 clones had some stalks with living terminal buds and 80% of the leaf area still green. Five of these clones were outstanding; all terminal buds were living and 95% of the leaf area was green. Several of these 5 clones had well developed flower buds. These buds were in the tender spindle area and would have emerged had the stalks not been cut (Fig. 1). The general appearance of these 5 clones contrasted sharply with the completely browned fields of commercial varieties.

One of these 5 clones, US 70-14-5, had an undesirable agronomic type; its thin stalk and narrow leaves recalled its wild ancestors, *S. spontaneum* Passorocean and *S. robustum*. The remaining 4 clones with superior cold tolerance were more promising. They were erect and had solid stalks and a high stalk population. These were US 66-56-4, US 66-56-7, US 66-56-9 and US 66-56-15. These clones are progeny of a cross between L 60-25 and US 56-15-8, a clone of *S. spontaneum* from Thailand. While these clones do not have the extreme tolerance to cold that Brandes' Uzbek clone had, they are much closer to commercial subtropical clones, both in agronomic type and in flowering behavior. Crosses between these new clones and our most cold-tolerant interspecific hybrids should result in varieties able to tolerate temperatures 1 to 3 degrees lower than our major varieties. Brandes original goal was no more than this; he stated that it would be worth millions to the industry (3).

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Figure 1. Internal tissue of the tops of sugarcane varieties after a 26 F freeze. Left and right, new clones showing no internal damage in any stalks. Center, CP 61-37, a cold tolerant commercial variety showed dead terminal buds and damaged stalk tissue in all stalks.

EVALUATION OF SUGARCANE VARIETIES FOR BORER RESISTANCE
BY ARTIFICIAL INFESTATION

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INTRODUCTION

In 1970, resistance of sugarcane varieties to the sugarcane borer, Diatraea saccharalis (F.), was evaluated at Houma, La. by the technique of artificial infestation. This method has been used for many years to select resistant varieties. For example, Patch and Peirce (1933) used artificial infestations to select corn varieties resistant to the European corn borer, Ostrinia nubilalis (Hubner), and Blanchard et al. (1942) used artificial infestations of corn earworm, Heliothis zea (Boddie), to select varieties of corn resistant to that insect. By using this technique to augment field populations of the pest insect, investigators may obtain more uniform infestations throughout the experimental area; vary levels of infestation to show the greatest difference between susceptible and resistant plants; eliminate from consideration some factors, such as oviposition preference; and control dates of infestation.

MATERIALS AND METHODS

The 1970 evaluations of varietal resistance to borer were conducted in 2 experiments. In Experiment I -- 23 L varieties, 46 CP varieties, and 77 US varieties, were planted in unreplicated 10 ft plots. Four check varieties, selected on the basis of known susceptibility to the borer, were planted randomly throughout the experimental area (nine replicates each). CP 48-103 and CP 52-68, are moderately susceptible; NCo 310, is the least susceptible variety grown commercially in Louisiana; and CP 66-491, selected as a resistant clone by McCormick in 1965; is probably the most resistant of the modern canes.

The CP and L varieties tested were the most promising of the 1964, 1965, 1966, and 1967 series. The US varieties tested were from new breeding lines, that show other desirable characteristics.

Heptachlor granules^{1/} were applied to the experimental area in June to reduce predation of the borer eggs and larvae.

During June and July, larvae and pupae of the sugarcane borer were collected from infested cane plants in the field. The pupae and larvae were reared to adults in the laboratory. The adults were allowed to oviposit on strips of wax paper, and small squares of wax paper with egg masses attached were pinned to the cane leaves. During July and August the plots were uniformly infested until all plots had received 1 egg mass/row-ft or about 250 to 300 eggs/10-ft plot.

Damage counts were made October 7-14, by cutting and stripping 10 mature stalks in each plot. Total joints and number of bored joints of each stalk were recorded. The percentage of joints bored was calculated, and the variance of the 4 check varieties was analyzed.

In Experiment II -- 2864 seedlings from 5 crosses were planted in the field in April. Using the same procedures as described in Experiment I, each clone was artificially infested with 2 average sized egg masses. In mid-October, each clone was examined for borer damage. Clones showing the least borer damage were selected and replanted to 6-ft plots to be more thoroughly screened for borer resistance in 1971.

RESULTS

Data from the 4 check varieties in Experiment I are summarized in Table 1. The technique of artificial infestation provided valid data since the 4 check varieties conformed to the previously predicted array with a relatively small error. The data from the test varieties are not given, however the CP and L varieties differed little in degree of borer injury. The range was from 34% to 81% bored joints and the mean was 57.9%. The US varieties had less damage. The mean was 33.7% bored joints and the range was 10 to 68%. Also 75 (97.4%) of the US varieties were as resistant or more resistant than CP 52-68.

Figure 1 indicated the differences between the US and the other varieties more clearly by showing the frequency of US clones and CP and L clones in 8 classes of percentage bored joints. The 69 CP and

^{1/} Mention of a pesticide in this paper does not constitute a recommendation of this product by the USDA.

L varieties (regular breeding program) are all found in the six highest classes of percentage, and the mode 56-65% bored joints. The varieties from the basic breeding program (US numbers) had from 10 to 68% joints bored, and the mode was 25 to 36%.

In Experiment II -- the seed from 224 clones was selected for further evaluation. These data are shown in Table 2. The average rate of selection was 7.8%. The highest rate was 16.7% from cross number 29 (NCo 310 x L 61-67) and the lowest rate was 4.2% from cross number 38 (CP 66-491 x CP 62-258).

DISCUSSION

Artificial infestations of sugarcane with egg masses of the sugarcane borer provided us with an effective means of establishing a uniform and high infestation. Most CP and L varieties proved to be relatively susceptible to this heavy pressure, which was not surprising since they had been selected by testing in moderate to light infestations. However, they did show a diversity of reaction. One variety, CP 67-404, had less than 35% bored joints, and 6 others had from 36 to 45% bored joints -- CP 67-361, CP 67-367, CP 67-491, CP 67-422, CP 67-430 and L 67-62.

The US varieties were more resistant than the CP and L varieties and are promising new sources of resistance. However, as a group, the US varieties tillered more profusely, were smaller in diameter, were lower in sucrose, and were higher in fiber than the CP and L varieties. We therefore must now determine whether apparently superior resistance is separable from their undesirable characteristics. However, with the diversity of genetic material available, the means of applying uniform selection pressure, and demonstrated selection efficacy, the development of varietal control in sugarcane should be attainable. Such control would reduce or eliminate the need for insecticides.

TABLE 1. Bored joints (%) in 4 varieties of sugarcane subjected to artificial infestation by sugarcane borers.

Variety	Percentage joints bored		Coefficient of variation (%)
	Mean	Range	
CP 48-103	69 ^{1/}	62-78	9
CP 52-68	59	49-71	10
NCo 310	51	41-60	12
CP 66-491	31	27-44	17

^{1/} All means were significantly different at 5% level of probability. Least significant difference at 5% level = 5.9.

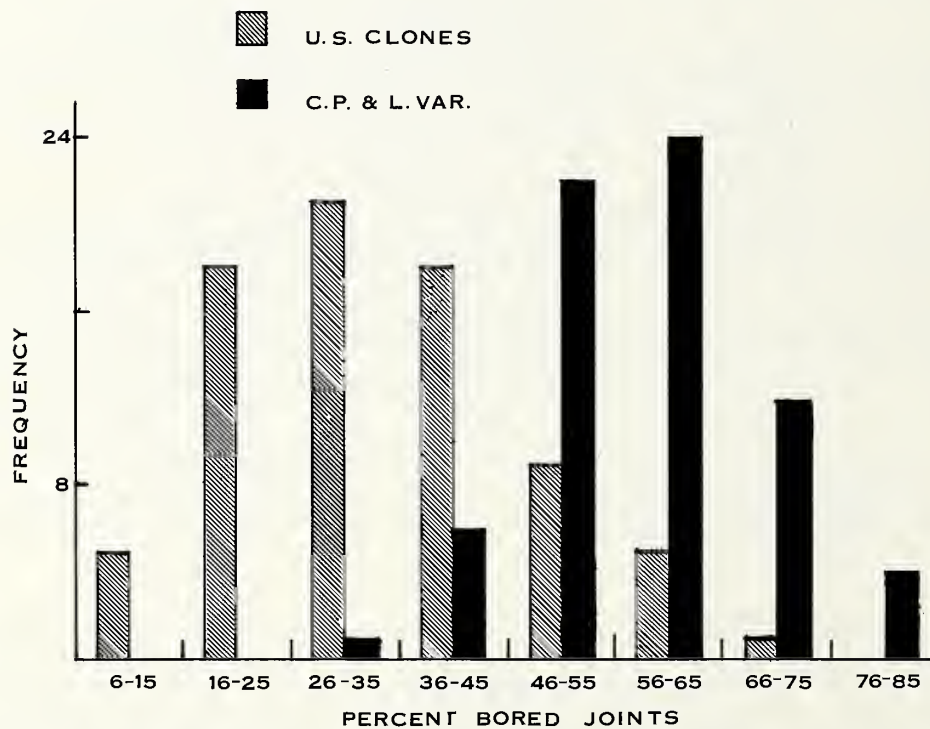
TABLE 2. Seedling selection for borer resistance at Houma, LA in 1970

Cross number	Parents	Number tested	Number selected	Percentage selected
3	NCo 310 x CP 64-307	316	24	7.6
15	CP 66-491 x CP 64-307	324	22	6.8
29	NCo 310 x L 61-67	12	2	16.7
38	CP 66-491 x CP 62-258	1238	52	4.2
249	CP 53-1 x CP 62-258	974	124	12.7
Total or average		2864	224	7.8

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Fig. 1. Number of varieties in each of eight classes of percentage bored joints after artificial infestation with sugarcane borer eggs at Houma, La., 1970.



EARLY TESTING FOR HIGHER YIELDING VARIETIES:
USDA INFIELD VARIETY PROGRAM

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ABSTRACT

During 1970, 500 varieties were tested in the infield variety program. These varieties came from the 1965, 1966, 1967 CP and L series, and the 1968 CP series. Yields of cane and sugar per acre are the most important of the criteria used in selecting varieties for advanced testing. Other important selection criteria are: erectness, brittleness, disease resistance, cold tolerance, time of maturity, inversion rate, growth rate, and hardness of stalks.

Data are reported for the 1967 series to illustrate the infield testing program.

INTRODUCTION

Successful sugarcane varieties in Louisiana must meet several special requirements. A satisfactory crop must be produced in 7 months as compared to 12 to 24 months in more tropical areas. Resistance to mosaic, ratoon stunting, red rot and root rot is essential for maximum yields. Early maturity and cold tolerance are necessary to avoid severe loss from early freezes. In addition, varieties for Louisiana must be erect and resistant to breakage, so that they can be harvested mechanically. Finally, varieties must have acceptable milling qualities and produce sufficiently high yields of cane and sugar per acre in plant and stubble crops for profitable production. All of these characters are routinely evaluated in the USDA infield testing program.

During 1970, the 1965, 1966, and 1967 CP and L varieties, and the 1968 CP varieties were included in infield tests. A total of 500 varieties were tested. The 1967 series will be used to demonstrate the information obtained in these tests.

STALK POPULATION

Yield of cane per acre is highly correlated with stalk population (5). Populations of 30,000 to 40,000 mature stalks per acre are necessary for maximum yields. We found varieties with 20,000 or more shoots in April or May usually produce an adequate number of mature stalks. Suckering during early summer increases the mature stalk population, but suckers that develop later usually fail to survive because of intense competition.

Table 1 shows spring shoot counts for the 1967 series. Counts were high for 7 of the 9 varieties selected for further testing. Some of these varieties had more than 30,000 shoots per acre in the stubble crops. CP 52-68, the standard, had less than 20,000 shoots per acre.

SUGARCANE MOSAIC VIRUS (SCMV)

The frequency of varieties in the selection program that are highly resistant to SCMV was increased in recent years. Some high yielding varieties were discarded because they were susceptible to SCMV, but there are mosaic resistant varieties in the program that produce high yields of sugar per acre (2). For example, CP 65-350 and L 65-69 have resistance comparable to CP 61-37 (Table 2) and produce high yields of sugar per acre. Studies on mosaic spread indicate resistance at least equal to CP 48-103 or CP 61-37 is needed in commercial varieties for Louisiana (3).

ERECTNESS AND BRITTLINESS

Louisiana's sugarcane crop is harvested entirely by machines designed to cut erect varieties. Although these harvesters can cut cane that is lodged to some extent, the cost of harvesting increases sharply with increased lodging. The 1970 crop was badly lodged and harvesters operated at slow speeds with frequent breakdowns. It was estimated (7) that as much as 10 tons of cane per acre were left in the field as scrap.

Lodging varies considerably from year to year and in any one year varieties differ in their tendency to lodge. Many varieties that yield above 30 tons of cane per acre lodge after heavy rains and/or winds in excess of 25 miles per hour. High-yielding erect varieties are continuously sought in our

selection program. We rate varieties for erectness on a numerical scale from 0 to 5. Zero indicates complete erectness, 1 indicates stalks are leaning 18 degrees, 3 indicates stalks leaning 54 degrees, and 5 indicates stalks are completely recumbent. Varieties given a rating of 3 or more are considered prone to lodge. Several varieties tested in 1970 (Table 3) were erect. Among these varieties were CP 67-320, CP 67-392, CP 67-411 and CP 67-412.

Lodged varieties that are not brittle can be harvested with less loss than those that are brittle. Stalk breakage due to excessive brittleness results in cane left in the field as scrap during the harvesting operation. An indication of degree of brittleness was obtained by measuring the amount stalks could be bent before breaking (4). A simple device was constructed for use in the field. CP 48-103 and L 60-25 are very brittle; CP 52-68 and L 65-69 are significantly less brittle. Only preliminary results are available for the 1967 CP and L series. CP 67-345 and CP 67-412 were about as brittle as CP 48-103. Other varieties in this series were no more brittle than variety CP 52-68.

VARIETAL CORRECTION FACTOR (VCF)

Varieties vary in the amount of sugar that can be extracted when the sucrose and Brix is the same in the crusher juice. The method used to calculate estimated yields of sugar per ton of cane at the Houma Station was described by Arceneaux (1) and reviewed by Legendre (8). A variety correction factor (VCF) is assigned to each variety for calculation of estimated yields of sugar per ton of cane. The reference variety Co 281 was assigned a VCF of 1.00. Variety correction factors for CP 52-68 and CP 67-345 are 1.02 and .98, respectively. Variety CP 52-68 should yield about 4% more sugar per ton of cane than variety CP 67-345. The varietal correction factors assigned to the 1967 CP series ranged from .94 to 1.04.

VISUAL RATINGS FOR TONS OF CANE PER ACRE

Visual ratings of each variety for tons of cane per acre are made independently by four agronomists on three dates during the growing season. The first rating is made in April or May and is primarily a rating of stubbling ability. The second rating is made in July and the third rating is made in late August. Ratings range from 1 to 10. Five is assigned to the standard variety included in the planting. The rating is increased or decreased by one for each estimated increase or decrease in yield above or below the standard variety. These ratings are used to select varieties for further testing. Actual yield data is not available at this stage of testing when selections are made for advancement to the next stage. For example, selections from the 1968 series were replanted on September 4, 1970, but the first yield data on the plant cane crop were not obtained until November 25, 1970.

Ratings for estimated yields of cane per acre in the 1967 series are shown in Table 4. An average ratings above 4 indicates sufficient vigor to warrant further testing. Varieties selected for further testing from the 1967 series received average ratings from 4.64 to 6.08. Average sucrose (% of standard) is also used in selection of varieties (Table 4). A variety is generally not retained for further testing if it is below 110% of standard, unless it exhibits unusual vigor. Sucrose content of varieties selected for further testing from the 1967 series ranged from 108 to 136% of the standard variety.

YIELDS OF CANE AND SUGAR

The most important selection criteria are yields of cane and sugar per acre. In advanced testing stages, yield of cane per acre is determined by weighing the entire plot. Sucrose content is determined by sampling each plot. All yield data are combined and used in selecting varieties for additional testing. Three years data are now available for the 1967 series (Table 5). CP 67-411, the highest yielding variety in the series, averaged 9,596 pounds of sugar per acre. CP 67-345, the lowest yielding variety, averaged 6,299 pounds of sugar per acre.

OTHER SELECTION CRITERIA

Several diseases other than mosaic virus are considered in testing new varieties for the Louisiana sugar industry. Among these are ratoon stunting, red rot, and root rot. Ratoon stunting disease is the most serious, and its effect on yield is measured in later testing stages.

High sucrose varieties may or may not be early maturing. Experiments in which sucrose content is determined at weekly intervals from September to December provide information on time of maturity. The best time to plant a particular variety is determined by planting on three dates, August 15, September 1 and October 1.

At more advanced stages of testing, ratings are made on resistance of stalks to freezing and deterioration, on resistance of leaves and buds to frost damage, and on stubbling ability (6). Rate of inversion of sucrose to simple sugars is determined for each variety by sampling periodically after cane is cut.

Some of the other characters that are measured include stalk diameter, stalk weight, growth rate and hardness of stalks. Resistance of stalks to puncture is measured in pounds per square inch with a penetrometer. Varieties with high hardness ratings tend to be high in fiber.

CONCLUSIONS

All of the information available for each variety is used in selecting candidates for more advanced testing. Prior to planting time each year, the four agronomists at the Houma Station carefully consider the strong and weak points of each variety and prepare a list of varieties for advanced testing. The large amount of information available at this time is made possible by the joint effort of agronomists, pathologists, physiologists, and entomologists.

The Advancement and Release Committee meets in June and September of each year to discuss and recommend varieties for final testing or release for commercial production. This committee is represented by members of the U.S. Department of Agriculture, the Louisiana State Experiment Station, and the American Sugar Cane League.

It is very important to the sugar industry to have the improved high-yielding varieties that are made available through research. It is equally important to recognize and discard varieties with weaknesses that could result in disastrous losses to the industry.

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TABLE 1. Stalk population of the '67 series during 1970.

: Shoots per acre				
Variety	: Plant Cane 2/	: First Stubble 3/	: Second Stubble 4/	: All Crops
CP 67-314	: 10,731	: 25,578	: 24,960	: 20,423
CP 67-320	: 19,110	: 32,046	: 13,440	: 21,532
CP 67-331	: 19,992	: 26,754	: 21,120	: 22,622
CP 67-334	: 12,054	: 30,870	: 22,560	: 21,828
CP 67-345 <u>1/</u>	: 15,582	: 27,489	: 18,240	: 20,437
CP 67-365	: 13,377	: 22,638	: 20,160	: 18,725
CP 67-367	: 13,671	: 19,845	: 11,520	: 15,012
CP 67-382	: 11,319	: 18,228	: 13,920	: 14,489
CP 67-384	: 14,259	: 20,433	: 10,080	: 14,924
CP 67-389 <u>1/</u>	: 20,286	: 29,988	: 36,000	: 28,758
CP 67-391	: 12,642	: 27,048	: 35,040	: 24,910
CP 67-392	: 19,845	: 21,315	: 14,880	: 18,680
CP 67-404 <u>1/</u>	: 17,052	: 33,516	: 30,240	: 26,936
CP 67-411 <u>1/</u>	: 11,172	: 18,816	: 18,720	: 16,236
CP 67-412 <u>1/</u>	: 20,139	: 27,195	: 38,400	: 28,578
CP 67-413 <u>1/</u>	: 19,257	: 30,870	: 32,160	: 27,429
CP 67-422 <u>1/</u>	: 22,050	: 33,075	: 17,280	: 24,135
CP 67-424 <u>1/</u>	: 13,230	: 28,518	: 24,960	: 22,236
CP 67-430 <u>1/</u>	: 20,727	: 28,518	: 15,840	: 21,695
CP 44-101	: 12,201	: 22,932	: 30,720	: 21,951
CP 48-103	: 14,550	: 20,286	: 14,400	: 16,412
CP 52-68	: 11,025	: 19,110	: 17,280	: 15,805
L 60-25	: 20,433	: 25,600	: 32,425	: 26,153
LSD .05	: -	: -	: -	: 8,359

1/ Selected for primary stations and outfield testing.2/ Counts made May 11, 1970.3/ Counts made April 21, 1970.4/ Counts made April 21, 1970.

TABLE 2. Mosaic Spread Experiments 1/.

: Weighted Average percent mosaic				
Variety	: Plant Cane 3/	: Plant Cane 4/	: First Stubble 3/	: All Crops
	6-23-69	6-16-70	6-23-70	
CP 67-314	: 0.4	: 5.4	: 16.5	: 7.4
CP 67-320	: 1.9	: 92.9	: 39.9	: 44.9
CP 67-331	: 1.9	: 13.9	: 12.7	: 9.5
CP 67-334	: 0.0	: 24.1	: 24.5	: 16.2
CP 67-345 <u>2/</u>	: 2.1	: 0.0	: 0.0	: 0.7
CP 67-365	: 0.0	: 0.0	: 7.8	: 2.6
CP 67-367	: 1.1	: 28.6	: 31.5	: 20.4
CP 67-382	: 0.0	: 2.3	: 20.7	: 7.7
CP 67-384	: 6.1	: 10.5	: 28.0	: 14.9
CP 67-389 <u>2/</u>	: 4.5	: 5.7	: 13.3	: 7.8
CP 67-391	: 2.1	: 10.7	: 19.1	: 10.6
CP 67-392	: 0.0	: 0.0	: 5.7	: 1.9
CP 67-404 <u>2/</u>	: 0.0	: 0.0	: 6.2	: 2.1
CP 67-411 <u>2/</u>	: 6.8	: 6.3	: 3.2	: 5.4
CP 67-412 <u>2/</u>	: 2.8	: 11.9	: 26.7	: 13.8
CP 67-413 <u>2/</u>	: 2.6	: 9.0	: 31.8	: 14.5
CP 67-422 <u>2/</u>	: 0.0	: 1.7	: 10.0	: 3.9
CP 67-424 <u>2/</u>	: 2.5	: 2.8	: 9.0	: 4.8
CP 67-430 <u>2/</u>	: 0.9	: 2.3	: 27.9	: 10.4
CP 48-103	: 0.4	: 2.7	: 14.0	: 5.7
CP 52-68	: 17.6	: 27.2	: 48.6	: 31.1
L 60-25	: 3.7	: 40.3	: 28.0	: 24.0
CP 61-37	: 0.4	: 2.7	: 8.8	: 4.0
LSD .05	: -	: -	: -	: 18.7

1/ Data from unpublished reports by R. L. Tippet and H. Koike.2/ Selected for primary stations and outfield tests.3/ Mosaic spread tests at the Houma Station.4/ Mosaic spread tests at Ronald Hebert.

TABLE 3. Ratings on erectness during 1970 1/.

Variety	: Plant Cane 2/	: First Stubble 2/	: Second Stubble 2/
CP 67-314	: 3	: 2	: 1
CP 67-320	: 0	: 2	: 0
CP 67-331	: 4	: 1	: 1
CP 67-334	: 3	: 3	: 0
CP 67-345 <u>3/</u>	: 2	: 2	: 0
CP 67-365	: 3	: 0	: 0
CP 67-367	: 4	: 4	: 2
CP 67-382	: 3	: 3	: 0
CP 67-384	: 4	: 3	: 2
CP 67-389 <u>3/</u>	: 3	: 3	: 1
CP 67-391	: 3	: 2	: 3
CP 67-392	: 0	: 0	: 0
CP 67-404 <u>3/</u>	: 3	: 2	: 1
CP 67-411 <u>3/</u>	: 0	: 0	: 0
CP 67-412 <u>3/</u>	: 1	: 0	: 0
CP 67-413 <u>3/</u>	: 2	: 0	: 0
CP 67-422 <u>3/</u>	: 2	: 3	: 0
CP 67-424 <u>3/</u>	: 3	: 3	: 3
CP 67-430 <u>3/</u>	: 4	: 4	: 2
CP 44-101	: 0	: 0	: 0
CP 52-68	: 0	: 0	: 0
L 60-25	: 4	: 4	: 3

1/ 0 = erect, 1-4 = intermediate, 5 = completely recumbent.

2/ Ratings made September 15, 1970.

3/ Selected for primary stations and outfield testing.

TABLE 4. Rating varieties of the '67 series for sucrose and tons of cane per acre during 1970.

		: Visual tonnage rating				
		: Sucrose %	: Plant	: First	: Second	:
Variety	: Control all analyses	: Cane	: Stubble	: Stubble	: Average	
CP 67-314	: 110 <u>2/</u>	: 3.75	: 5.25	: 4.63	: 4.23	
CP 67-320	: 110	: 5.50	: 6.00	: 3.62	: 5.04	
CP 67-331	: 106	: 4.67	: 6.00	: 4.88	: 5.18	
CP 67-334	: 116	: 3.83	: 4.75	: 4.75	: 4.44	
CP 67-345 <u>1/</u>	: 110	: 4.92	: 5.00	: 4.00	: 4.64	
CP 67-365	: 112	: 4.00	: 4.13	: 3.63	: 3.92	
CP 67-367	: 118	: 4.92	: 5.75	: 3.75	: 4.81	
CP 67-382	: 118	: 5.00	: 4.88	: 4.38	: 4.75	
CP 67-384	: 117	: 5.08	: 5.00	: 3.63	: 4.57	
CP 67-389 <u>1/</u>	: 112	: 5.42	: 5.75	: 5.75	: 5.64	
CP 67-391	: 116	: 4.67	: 5.50	: 5.25	: 5.14	
CP 67-392	: 125	: 4.67	: 4.88	: 3.50	: 4.35	
CP 67-404 <u>1/</u>	: 115	: 5.33	: 6.04	: 5.38	: 5.58	
CP 67-411 <u>1/</u>	: 108	: 4.92	: 5.75	: 5.00	: 5.22	
CP 67-412 <u>1/</u>	: 116	: 5.50	: 6.25	: 6.50	: 6.08	
CP 67-413 <u>1/</u>	: 113	: 5.67	: 6.00	: 6.25	: 5.97	
CP 67-422 <u>1/</u>	: 136	: 4.50	: 5.88	: 4.25	: 4.87	
CP 67-424 <u>1/</u>	: 132	: 5.50	: 6.13	: 5.75	: 5.79	
CP 67-430 <u>1/</u>	: 109	: 6.08	: 6.25	: 5.00	: 5.78	

1/ Selected for primary stations and outfield testing.

2/ % of control variety.

TABLE 5. Combined variety yields of CP '67 series (2 plant cane + 1 first stubble).

Variety	Yield of cane			Yield of sugar		
	per acre		per ton	per		per
	tons	pounds	of cane	acre	ton	ton
CP 67-411 <u>1/</u>	: 41.58	: 230.77	: 9596 a	<u>2/</u>		
CP 67-422 <u>1/</u>	: 36.35	: 248.90	: 9049 a	b		
CP 67-424 <u>1/</u>	: 38.28	: 234.51	: 8974 a	b		
CP 67-412 <u>1/</u>	: 36.75	: 214.64	: 7910 a	b c		
CP 67-404 <u>1/</u>	: 32.33	: 236.38	: 7651 a	b c		
CP 67-430 <u>1/</u>	: 33.70	: 224.70	: 7565 a	b c		
CP 67-413 <u>1/</u>	: 33.90	: 223.08	: 7547 a	b c		
CP 67-389 <u>1/</u>	: 36.25	: 199.50	: 7221	b c		
CP 48-103	: 30.74	: 232.62	: 7162	b c		
CP 44-101	: 39.61	: 180.18	: 7125	b c		
CP 52-68	: 35.01	: 199.67	: 6978	b c		
CP 67-345 <u>1/</u>	: 31.94	: 195.70	: 6299	c		
LSD .05	: 8.71	: 26.85	:			

1/ Selected for primary and outfield tests.2/ Means followed by the same letter are not significantly different at the 5% level of probability

NITRIFICATION INHIBITORS APPLIED WITH ANHYDROUS AMMONIA TO SUGARCANE

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ABSTRACT

Two nitrification inhibitors, potassium azide (KN_3) and N-Serve [2-chloro-6-(trichloromethyl) Pyridine], were formulated in anhydrous ammonia at levels of 3% and 6% by weight and applied to sugarcane with a special field applicator at rates of 100 and 150 pounds of N per acre. The point of ammonia release in soil was marked at the time of injection by means of special assemblies for placing nylon string just behind the applicator knives. This facilitated accurate and precise sampling of the ammonia retention zone, throughout the growing season, for analysis of residual ammonium (NH_4^+) and nitrate (NO_3^-) produced by nitrification. The order of nitrification inhibition in soil was: $\text{NH}_3 + \text{N-Serve} > \text{NH}_3 + \text{KN}_3 > \text{NH}_3$ alone. The greater residual activity of N-Serve was apparently related to its low solubility in soil water, compared to the high solubility of KN_3 and its greater leaching potential. Ammonia alone was almost completely nitrified after 4 weeks while N-Serve with ammonia caused a significant suppression of nitrification for 12 weeks.

MATURITY STUDIES OF COMMERCIAL SUGARCANE VARIETIES IN FLORIDA

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ABSTRACT

There is a need for sugarcane varieties high in sucrose content when the harvest season begins in Florida. It is also important that these varieties continue to accumulate sugar for the duration of the long season or, if the standing cane is subjected to freezing temperatures, they do not suffer too serious loss in available sugar.

A 2-year study of maturation patterns of 6 commercial varieties revealed important differences in the amounts of Brix and sucrose in the different one-third segments of C1 41-223, CP 50-28, CP 56-63, CP 57-603, CP 57-614, and CP 62-374. The 2 late-maturing varieties, C1 41-223 and CP 57-603, contained relatively less sugar in the upper one-third segments than the other 4 varieties in both the plant crop in 1968 and the first-stubble crop in 1969 when samples were taken on November 1. On March 1 the differences among segments were much less than they were on November 1 each year.

Although the differences in whole stalk weights were statistically significant, they were not as large as in Louisiana where the season is not as long. There were real differences in the total amount of sugar present in the stalks of different varieties on November 1 and in the rate at which the different varieties accumulated sugar during the harvest season. For example, while CP 57-603, a late-maturing variety, showed an increase of 73.2 lbs of available sugar in the first 93 days, as plant cane and 29.9 lbs as first stubble in the same period, CP 56-63, an early-maturing variety, gained only 24.9 lbs in plant cane and 5.2 lbs in first stubble during the first 30-day period each year. There was less sugar in CP 56-63 on March 1 than on November 1 each year. Minimum temperatures of 27°F on December 16, 1968 and 30°F in early January 1970, did not cause serious losses in available sugar in either harvest season with the varieties in our experiments.

ROLE OF CHEMICAL INSECTICIDES, PARASITES AND PREDATORS IN CONTROL OF THE SUGARCANE BORER IN FLORIDA, 1965-1970

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ABSTRACT

The annual loss as determined by annual harvest-time borer surveys are presented. Chemical control experiments and role of parasites and predators in control of the borer in Florida are discussed.

PATTERN OF GERMINATION AND CONTROL OF ROTTBOELLIA EXALTATA

L.F. (RAOULGRASS) WITH TRIFLURALIN AND TERBACIL

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ABSTRACT

Raoulgrass has become an important grass weed in Louisiana sugarcane during the past 20 years because it has not been controlled effectively with most herbicides. We conducted several experiments in an abandon sugarcane field that was heavily infested with raoulgrass; the soil was rototilled to a depth of 7 inches and bedded, but no sugarcane was planted. Some raoulgrass germinated following each rain; in one experiment, germination occurred at 8 separate periods from April to July. Seed germinated from a wide range of depths, from the soil surface to depths of about 6 inches. No definite pattern could be established between depth of seed and the date of germination during the year, but most seed seemed to germinate from the top 2 inches in April and May and from the top 4 inches in June and July. The herbicides a,a,a-trifluro 2,6-dinitro-N,N-diprophl-p-toluidine (triflurlin at 2 lb/A or 3-tert-butyl-5-chlor-6-methyluracil (terbacil) at 3.2 lb/A, incorporated 2 inches deep in silt loam soil in April, controlled germinating raoulgrass almost completely for 60 days. Control after 90 days was 80% and 90% for terbacil and trifluralin, respectively. In another experiment, trifluralin incorporated on a 36-inch band directly over plant sugarcane in March also controlled raoulgrass until layby in June without crop injury.

In greenhouse experiments, seeds of raoulgrass were planted in or below a 2-inch layer of soil that had been uniformly mixed with trifluralin or terbacil; water was applied by subirrigation.

Terbacil at 1.6 or 3.2 lb/A was toxic to shoots of raoulgrass when seeds were planted directly in treated soil. A rate of 3.2 lb/A was also toxic to plants emerging from below treated soil. All plants emerged from soil, but within a week leaves became chlorotic and shoots died. Terbacil did not suppress growth of roots; secondary roots formed normally on both the primary root and the first internode (mesocotyl).

Plants responded differently when growing in or through soil treated with trifluralin as compared with plants growing in soil treated with terbacil. When planted in soil treated with trifluralin at rates of 1/8, 1/4, 1/2, and 1 lb/A, primary roots grew only about 1/2 inch. At rates of 1/2 or 1 lb/A, the first internode ceased growing upon entering treated soil and the shoot did not emerge. At 1/4 lb/A most shoots emerged and survived from seed planted 1/2 inches deep in treated soil, but shoots did not emerge from seed planted 1 inch below treated soil. A rate of 1/8 lb/A was generally nonphytotoxic to plants that germinated from either depth. Neither trifluralin nor terbacil controlled raoulgrass effectively if sprayed on the soil surface without incorporation.

EFFECTS OF SUBSOILING ON THE PRODUCTION OF SUGARCANE

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ABSTRACT

Experiments were conducted to determine the effects of subsoiling with a vertical mulcher type of subsoiler on the yield of sugarcane. The vertical mulcher was designed to open a furrow approximately 26 inches deep and 10 inches wide at the soil surface for incorporating organic material into the subsoil. The vertical mulcher was operated under each row prior to building the rows for planting. The cane yield obtained with the vertical mulcher was compared with yields obtained with a regular type of subsoiler and without subsoiling.

Results from several experiments indicated that significant yield increases were obtained from subsoiling under the row prior to planting in soils with a subsoil compacted by the use of heavy field equipment. Significantly higher yields were produced with the vertical mulcher than with the regular subsoiler. The incorporation of partially decomposed bagasse into the soil with the vertical mulcher did not increase yield over subsoiling alone. The increases in yield from subsoiling with the vertical mulcher were more pronounced in sandy soils than in clay soils and more in plant cane than in stubble cane.

PHYSICAL AND MECHANICAL PROPERTIES OF SUGAR CANE

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ABSTRACT

This presentation is a progress report of some sugar cane properties tests that have been conducted in Louisiana. Tests and equipment have been designed to evaluate strength properties of several Louisiana varieties when subjected to bending, tension, and compression loads. Properties of density, fiber content, and hardness were also evaluated to see if they were correlated with the mechanical properties (ultimate force, maximum deflection, and rupture energy in bending, or ultimate stress, strain, and modulus of elasticity in compression).

No significant correlation was found to exist between the physical and mechanical properties evaluated. However, there were significant varietal differences within most of the properties. The differences found in 1970 within varieties NCo-310, CP 52-68, L 60-25, CP 61-37, L 65-69, and CP 65-350 will be presented.

Refinements of the testing techniques and conditions (sample preparation, sample size, loading rate, drying rate, etc.) have been made during the past season and will undoubtedly be made as new tests are introduced. Plans are being made to add an impact test which will yield data useful to both machinery designers and the varieties selection committee. Other properties tests need to be initiated, e.g. develop a means for quantitatively determining the shucking characteristics of different varieties. Properties tests should be further selected and scaled to include all new varieties that are introduced to the primary stations and test field system.

TWO-ROW SUGAR CANE HARVESTING COMBINE

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ABSTRACT

The rising cost of imported laborers to hand cut the sugar cane was the major factor which led to the harvesting program discussed in this report. In 1968 and 1969 Osceola Farms Company, Canal Point, Florida, USA purchased a group of three Model S-6 cane harvesters built by J & L Engineering Company, Jeanerette, Louisiana, USA. These machines cut two rows of cane, regardless of the state of recumbency, and then chop and load it into carts in one continuous operation. So far in the 1970-71 crop, 43,000 tons of sugar cane have been harvested at an average rate of 590 tons per 10 hour day. Harvesting cost at this rate was \$1.65 per ton, which compares favorably with the present cost of approximately \$2.45 per ton for cane which is hand cut and then loaded with continuous loaders. A sustained harvesting rate of 950 tons per day was reached in December and maintained for a period of more than a week. The results of the tests indicate that, with minor modifications to increase machine availability, a group of three machines could harvest 1000 tons per 10 hour day, and under good conditions up to 70 tons per hour can be harvested per machine. Trash content of the harvested cane was not a problem this season due to the early freezes and ability of the machines to effectively top cane that is standing upright. Generally speaking, the trash content of the machine cut cane has been in the range of 8 to 12%. There have been other apparent losses associated with the mechanical harvesting, such as sucrose losses and cane losses. However, these have not been accurately determined or diagnosed as yet and we believe that additional tests must be run before these factors can be properly analyzed.

THOUGHTS ON SUGAR HOUSE WASTE STREAMS

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ABSTRACT

Waste stream is one of the aspects of "Pollution". This word is in everyone's thoughts, but may not be to everyone's understanding. So much has been talked about, yet so little is actually known. In order to make plans for treatment and handling, the stream flows have been carefully analyzed and diagnosed. Based on the continuous data obtained, and comparing the quality/quantity to what is required, some treatments have been introduced and their results evaluated. The main criteria are pH, temperature, DO and BOD. With a combination of spray-cooling, aeration-sedimentation, and impounding, some impressive results have been achieved. The surface aerator has proved to be a good tool for odor. The adjustment of flows could be very effective in avoiding the final discharge from exceeding some maximum limits.

ABOUT MASSECUITE SYSTEMS

$$y = f(x)$$

Guillermo Aleman
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The advantages and/or disadvantages of the several massecuite systems have been discussed at length for a long time, so we do not intend or presume to be bringing up anything new to the studious sugar technologist. However, since there still seems to exist some misunderstandings and fears as to the new systems, we have found it convenient to express our views on the subject.

First, let us point out that the distinction between systems of massecuites we are concerned with in this paper is just the one that qualifies them by the number of steps or the composition (purity) of each step in which the exhaustion of the molasses is accomplished.

For the benefit of those not closely related with this matter, it is necessary to recall that conventionally the exhaustion of the molasses had to be done in three steps at least: but with the introduction of the "graining up" in a medium of low purity (molasses or mixture of molasses and syrup), it became possible to achieve the exhaustion in a fewer number of steps or to shorten the distance between the initial step (A Massecuite) and the final step (C Massecuite).

As everybody knows, this improvement brought about great advantages from a chemical point of view that nobody dares to deny, but it was questioned and still is in some instances from what we could call a "mathematical point of view."

The objections to the new procedure (which is no longer new) are based mainly on the assumption that the elimination in some cases, or the increase of the purity in some other cases, of the intermediate or "B" massecuite of the conventional system would result in an increase of the "C" massecuite and/or its purity, affecting, as a result, the amount and/or purity of the Final Molasses. Business-wise, it would amount to saying that the new processes put more sucrose in Final Molasses and less in sugar crystals than the conventional processes.

Of course, there is no real mathematical basis for the above thought, since "mathematically," the amount of sucrose that goes to the Final Molasses is neither more nor less than just a function of the purity of the Final (C) massecuite for a given initial purity (purity of the syrup in this case) independently of the system or intermediate purities used.

That is, $y = f(x)$, where y is the amount of sucrose going to the Final Molasses (dependent variable) and x is the purity of the Final massecuite (independent variable in this case). That is, " y " is a function of " x ".

Let us point out clearly that in this case we are referring to the matter mathematically, not chemically.

With the above in mind, let us compare what happens mathematically, step by step, in two different systems with the same purities in the syrup and in the Final Massecuite.

Conventional Three Boiling System:

Figure No. 1 shows the mathematical flow of Pol (and we use the figure Pol and not sucrose because what is really reflected in our technical reports is Pol, even though most of the time it is referred to as "sucrose").

But since what we are going to do is a comparison, and we will be using the same figures in both instances, this comparison is valid, and do not be surprised if, following the common practice, we use the terms Pol and Sucrose indiscriminately, as though they were the same thing.

Let us figure out 10,000 cubic feet of "A" Massecuite of 94° Brix and 86% Purity in a Vacuum Pan Department receiving syrup of 85.42% Purity and "C" sugar seed of 90% Purity.

The composition of this 10,000 c.f. of "A" Massecuite will be as follows:

$$\begin{aligned} 10,000 \times 94.097 &= 940,970 \text{ lbs. of massecuite.} \\ 940,970 \times .94 &= 884,512 \text{ lbs. of solids.} \end{aligned}$$

These 884,512 lbs. of solids were formed out of 112,000 lbs. of solids of 90% purity from "C" sugar seed and 772,512 lbs. of solids from syrup of 85.42% purity combined in the 884,512 lbs. of solids of 86% purity, it equals the 760,680 lbs. of Pol contained in the Massecuite.

If this Masecuite is properly cooked in the vacuum pans and dried in the centrifugal without needing much washing, it must render a drop of purity of about 20° to its molasses. And then, applying the "crystal yield" formula, we will have:

$$\frac{76,680 \times 100 (86 - 66)}{86 (100 - 66)} = 520,305 \text{ lbs. of Pol to A sugar.}$$

$$760,680 - 520,305 = 240,375 \text{ lbs. of Pol to A Molasses.}$$

$$240,375 \text{ } \%. \quad .66 \quad = \quad 364,204 \text{ lbs. of solids in A Molasses.}$$

For those not familiar with this matter, let us explain that the crystal yield formula comes from the mathematical development of the fundamental equation:

$$\text{Sucrose in Sugar} + \text{Sucrose in Molasses} = \text{Sucrose in Masecuite.}$$

This formula is purely mathematical and does not reflect or take into account any of the different chemical reactions that may and do take place during the crystallization of sucrose out of one impure solution, mainly when heat is an element of the operation.

But now we are dealing with the mathematical aspect of the question, so let us go on with the best tools available, keeping the above in mind because at the end we will have something to do with the chemical aspect of the matter.

Out of that "A" molasses, we will make a "B" Massecuite of 72% purity in the following way:

Those 364,204 lbs. of solids of 66% purity will be combined with 61,701 lbs. of solids of 90% purity from "C" sugar seed and 79,976 lbs. of solids of 85.42% purity from syrup.

All this will sum up, as is shown in the Flow diagram, to a "B" Masseccuite composed of 505,881 lbs. of solids of 72% purity, equal to 364,221 lbs. of Pol.

This "B" Masseccuite, properly boiled and dried, must give us "B" molasses of about 52% purity which means a reasonable 20° drop in purity.

In the Flow diagram we see how this Massequite will render 210,775 lbs. of Pol in "B" sugar and 153,446 lbs. of Pol in "B" Molasses; these last equivalent to 295,088 lbs. of solids of 52% purity.

Now, with these 295,088 lbs. of solids in "B" molasses, we are ready to make our "C" massecuite.

We chose the purity of 60% for this massecuite, which is a value commonly used as an average and it will be the X in our functional expression.

To obtain the 60% purity we have to add 92,868 lbs. of solids of 85.42% purity from our syrup and will result in the 387,956 solids of 60% purity containing 232,774 lbs. of Pol in the "C" Massequite.

This Masecuite, boiled under fair conditions, cooled off regularly, and properly dried, must drop the purity of its molasses down at least 27°, that is, the Final Molasses will be about 33% purity. The purity of the "C" sugar should be no less than 90%, so let us use this figure.

Out of the crystal yield formula we find that the turn out of the above Massecuite is 156,331 lbs. of Pol in "C" sugar of 90% purity and 76,443 lbs. of Pol in Final Molasses of 33% purity.

So, all in all, we have used:

659,880 + 68,315 + 79,328 = 807,523 lbs. of Pol from syrup of 85.42% purity, and have produced
520,305 + 210,775 = 731,080 lbs. of Pol in sugar plus 76,443 lbs. of Pol in Final Molasses.

731,080 + 76,443 = 807,523 lbs. of Pol balancing what we put in syrup.

In doing the above, we have boiled:

884,512 + 505,881 = 1,390,393 lbs. of solids in our A & B Massecuites to produce the 731,080 lbs. of Pol in production sugar.

Another thing to be pointed out is the 79,328 lbs. of Pol in the 92,868 lbs. of solids of 85.42% purity from syrup that we have sent through the "C" massecuite.

NEW SYSTEMS:

As to the steps or boilings (number of masseuites in the process), we have two new systems, one is the plain "Two Boiling System," the other took the name of "Two and a Half Boiling System."

The difference between them is that when the purity of the syrup is too high to obtain A molasses of proper low purity to keep the "C" massecuite under regular purity, in the plain "Two Boiling" some

A molasses is boiled back in the A massecuite, while in the "Two and a Half" two different "A" Masseccuites are produced; one virgin or A-1, and another with molasses from A-1, called A with Molasses, or A-2.

We are going to use for the comparison with the conventional Three Boiling the Two and a Half because we have figured, as you will have noticed, a rather high purity syrup and we particularly do not like to boil back molasses.

Now, let us see what happens mathematically when we put the same solids of 85.42% purity from syrup to work in a system that eliminates the 72% purity "B" massecuite.

As can be seen in figure No. 2, we will make a virgin massecuite named A-1 with the same purity as the "A" of the conventional system, that is 86%. Its composition is 94,994 lbs. of solids of 90% purity from "C" sugar containing 85,494 lbs. of Pol combined with 655,006 lbs. of solids of 85.42% purity from syrup, making a total of 750,000 lbs. of solids of 86% purity containing 645,000 lbs. of Pol.

Assuming the same purity drop as before, this massecuite will render molasses of about 66% purity.

Then, by crystal yield calculations:

$$\frac{645,000 \times 100 (86-66)}{86(100-66)} = 441,180 \text{ lbs. of Pol to A-1 sugar}$$

$$645,000 - 441,180 = 203,820 \text{ lbs. of Pol to A-1 molasses.}$$

$$203,820 \cdot /. .66 = 308,818 \text{ lbs. of solids in A-1 molasses.}$$

Most of this A-1 molasses is used for the making of the A-2 massecuite and the rest will serve for the making of the "C" massecuite.

A-2 massecuite: This is an "A" massecuite which purity is controlled by the addition of A-1 molasses. In this manner, we bring its purity down to the value needed for it to render the purity of A-2 molasses that we need.

As is depicted in the Flow diagram, we chose the purity of 78% for the A-2 massecuite, which with 20° purity drop will give us A-2 molasses of about 58% purity.

The components are 78,707 lbs. of solids of 90% purity from "C" sugar containing 70,836 lbs. of Pol, 278,924 lbs. of solids of 85.42% purity from syrup containing 238,257 lbs. of Pol and 251,160 lbs. of solids of 66% purity containing 165,766 lbs. of Pol from A-1 molasses totalling or combining into 608,791 lbs. of solids of 78% purity, equivalent to 474,859 lbs. of Pol for the A-2 massecuite.

Now,

$$\frac{474,859 \times 100 (78 - 58)}{78(100 - 58)} = 289,901 \text{ lbs. of Pol to A-2 sugar.}$$

$$474,859 - 289,901 = 184,958 \text{ lbs. of Pol to A-2 molasses.}$$

In this manner we reach our new "C" Masseccuite and we are able to make it of the same purity as the one we made in the conventional system.

From A-1 molasses we have 308,818 lbs. of solids minus 251,160 lbs. used in the A-2 massecuite, equal to 57,658 lbs. left to the C Masseccuite.

$$57,658 \times .66 = 38,054 \text{ lbs. of Pol.}$$

From syrup we have:

807,523 - 559,506 + 238,257 = 9,760 lbs. Pol from syrup left to the C Masseccuite. That is, not used in the A-1 and A-2 Masseccuite.

$$9,760 \cdot /. .8542 = 11,426 \text{ lbs. of solids.}$$

Combining the above left solids with the 318,893 lbs. of solids from the A-2 molasses, we obtain a "C" Masseccuite with a total of 387,977 lbs. of solids of 60% purity, equal to 232,772 lbs. of Pol.

As can be easily noticed, this is the same total composition of the "C" Masseccuite in the conventional system.

With the same purity drop, mathematically it will render C sugar and final molasses in the same amount and of the same composition as the C Masseccuite in the conventional system.

$$\frac{232,772 \times 100 (60 - 33)}{60 (100 - 33)} = 156,330 \text{ lbs. of Pol to C sugar.}$$

$232,772 - 156,330 = 76,442$ lbs. Pol to C molasses.

In brief, we find that with the "Two and a Half" system we have used:

$559,506 + 238,257 + 9,760 = 807,523$ lbs. of Pol from syrup, similar to what we used in the conventional system.

We have produced $441,180 + 289,901 = 731,081$ lbs. of Pol in A-1 and A-2 sugar, similar to what we did in the conventional system.

$807,523 - 731,081 = 76,442$ lbs. of Pol going into the final molasses, similar to what we had in the conventional system.

But we have boiled $750,000 + 608,791 = 1,358,791$ lbs. of total solids in the A-1 and A-2 Massecuite, that is: $1,390,393 - 1,358,791 = 31,602$ lbs. less than what we did in the conventional system.

In the new system we are employing just 11,426 lbs. of solids from syrup in the making of the C Massecuite, while in the conventional system we had to use 92,868 lbs. That is, in the new system 81,442 lbs. of solids from the syrup have been spared from going through the "C" Massecuite complex.

So, even mathematically, the 2-1/2 system has been proven to be a better one than the conventional 3 Boiling System and that there is no reason to fear that it could take more sucrose to the final molasses.

We have just said, "even mathematically," for it is not in this aspect where the main advantages of the new system is to be found.

When we explained about the development of the crystal yield formula, we said that we would return again to discuss the chemical influence on it.

Well, the fact that in the new system the amount of total solids to be boiled are much less than in the conventional system brings the actual figures closer to the mathematical ones because the damages from chemical reactions are diminished.

At the same time, the A-2 Massecuite sugar does not need the washing in the centrifugals that the "B" Massecuite sugar requires, decreasing in this manner the amount of solids returned in molasses to the vacuum pans.

The new system permits the "graining up" in a medium of low purity, instead of the high purity medium required by the conventional system.

We have just enumerated some of the chemical advantages of the new system without elaborating about them, as the scope of this paper was intended with a mathematical and not a chemical approach.

"A" Mass
Purity 86%

"A" Sugar
520,305 LBS. POL
Production

Syrup
659,880
LBS. POL

"C" Sugar Seed
100,800
LBS. POL

"A" Molasses
TO "B" MASSECUTE

Purity: 66%
240,375
LBS. POL

CONVENTIONAL 3 BOILING SYSTEM

FIGURE No 1

"B" Mass
Purity 72%

"B" Sugar
210,775 LBS. POL
Production

"C" Sugar
55,531 LBS. POL
Syrup
68,315 LBS. POL

"B" Molasses
TO "C" MASSECUTE

Purity: 52%
240,375
LBS. POL

"C" Mass
Purity 60%

"C" Sugar
156,331 LBS. POL
90% Purity
Production

Syrup
79,328
LBS. POL

"B" Molasses
153,446
LBS. POL

FINAL MOLASSES
76,443 LBS. POL
Purity 33%
Production

TO A & B MASSECUTE

"A"

MASSECUTE
COMPOSITION

	LBs. Solids	LBs Pol	Purity
FIZOM	112,000	100,800	90.00
"C" Sugar	772,512	659,880	85.42
Syrup	—	—	—
"A" Mol.	—	—	—
"B" Mol.	—	—	—
TOTAL	884,512	760,680	86.00

CRYSTAL YIELD: $\frac{86(100-66)}{100} = .684$

760,680 x .684 = 520,305 LBS POL "A" Sugar
760,680 - 520,305 = 240,375 LBS POL "A" Mol.
240,375 ÷ .66 = 364,204 LBS Solids "A" Mol.

"B"

MASSECUTE
COMPOSITION

	LBs. Solids	LBs Pol	Purity
FIZOM	61,701	55,531	90.00
"B" Sugar	79,976	68,315	85.42
Syrup	—	—	—
"A" Mol.	—	—	—
"B" Mol.	—	—	—
TOTAL	505,881	364,221	72.00

CRYSTAL YIELD: $\frac{72(100-52)}{100} = .5787$

364,221 x .5787 = 210,775 LBS POL "B" Sugar
364,221 - 210,775 = 153,446 LBS. POL "B" Mol.
153,446 ÷ .52 = 295,088 LBS Solids "B" Mol.

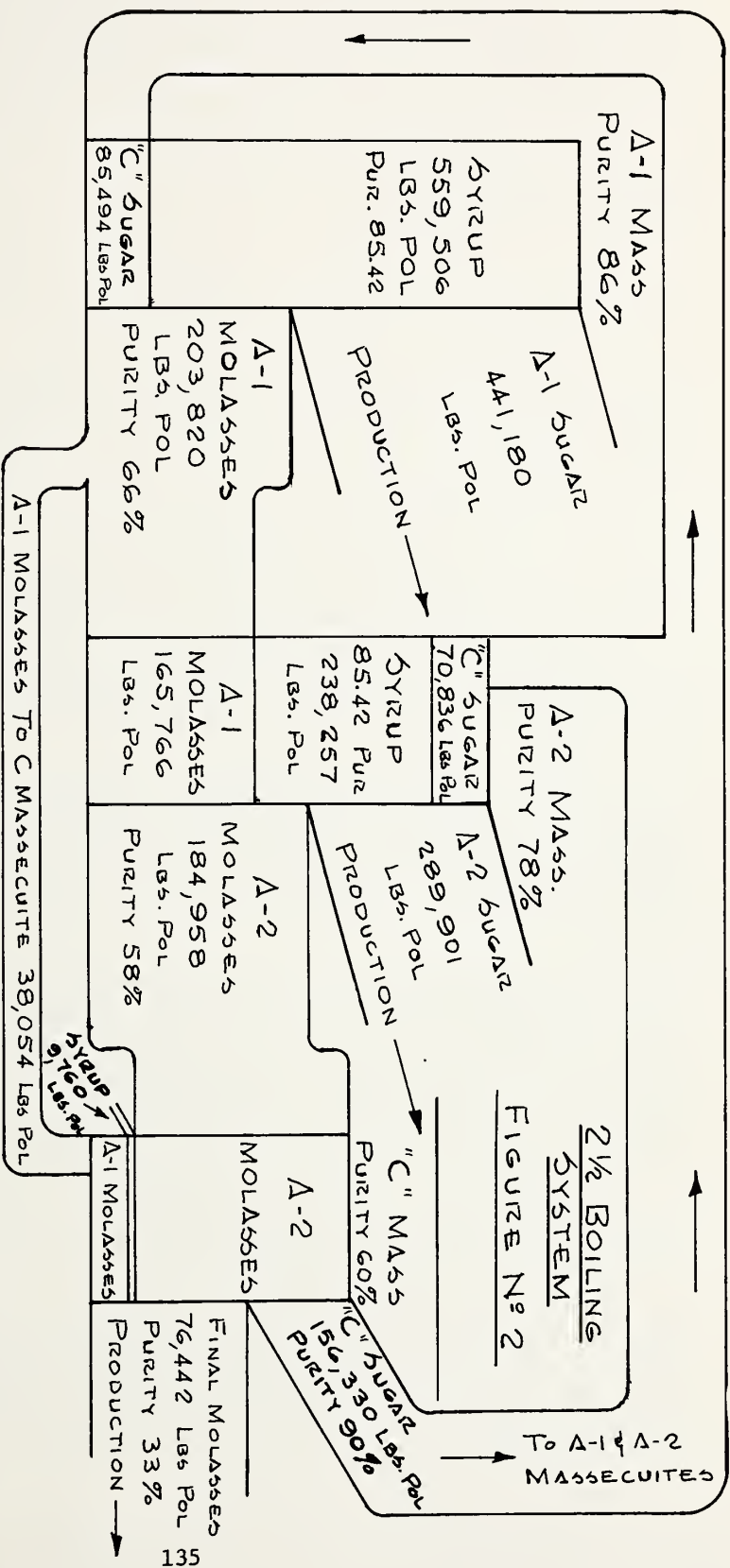
"C"

MASSECUTE
COMPOSITION

	LBs. Solids	LBs. Pol	Purity
FIZOM	—	—	—
"C" Sugar	92,868	79,328	85.42
Syrup	—	—	—
"A" Mol.	—	—	—
"B" Mol.	—	—	—
TOTAL	295,088	153,446	52.00

CRYSTAL YIELD: $\frac{60(100-33)}{100} = .6716$

232,774 x .6716 = 156,331 LBS POL "C" Sugar
232,774 - 156,331 = 76,443 LBS POL FINAL Mol.
76,443 ÷ .33 = 232,774 LBS Solids "C" Mol.
G. ALLENMAN



"A-1"

MASSSECUTE COMPOSITION

FROM	LBs. Solids	LBs. Pol	Purity
"C" Sugar	94,994	85,494	90.00
Syrup	655,006	559,506	85.42
A-1 Mol.	—	—	—
A-2 Mol.	—	—	—
TOTAL	750,000	645,000	86.00

CRYSTAL YIELD: $\frac{100 (86-66)}{86 (100-66)} = .684$

$645,000 \times .684 = 441,180$ Lbs Pol To A-1 Sugar
 $645,000 - 441,180 = 203,820$ Lbs Pol To A-1 Mol.
 $203,820 \div .66 = 308,818$ Lbs Solids In A-1 Mol.

"A-2"

MASSSECUTE COMPOSITION

LBs. Solids	LBs. Pol	Purity
78,707	70,836	90.00
278,924	238,257	85.42
251,160	165,766	66.00
608,791	474,859	78.00

CRYSTAL YIELD: $\frac{100 (78-58)}{78 (100-58)} = .6105$

$474,859 \times .6105 = 289,901$ Lbs Pol To A-1 Sugar
 $474,859 - 289,901 = 184,958$ Lbs Pol To A-1 Mol.
 $184,958 \div .58 = 318,893$ Lbs Solids In A-1 Mol.

"C"

MASSSECUTE COMPOSITION

LBs. Solids	LBs. Pol	Purity
11,426	9,760	85.42
57,658	38,054	66.00
318,893	184,958	58.00
387,977	232,772	60.00

CRYSTAL YIELD: $\frac{100 (60-33)}{60 (100-33)} = .6716$

$232,772 \times .6716 = 156,330$ Lbs Pol To "C" Sugar
 $232,772 - 156,330 = 76,442$ Lbs Pol To "C" Mol.

AUTOMATIC CANE JUICE SAMPLING

Adalberto Alfonso, Jr.
Atlantic Sugar Association
Belle Glade, Florida

The cane sampling method previously used at Atlantic Sugar Association was as follows: A laboratory was located at the scale house. The scale operator checked the cane brought to the sugar mill from each grower and a sample was taken every 65 tons. The samples were taken from the trucks by a small hydraulic crane. The samples were crushed in a small mill installed inside the lab and juice samples were taken for analysis. Analyses were done by a chemist and two assistants.

Several deficiencies in this system were:

- (1) The cane crushed in the sample mill was not as representative of that crushed in the large sugar mill.
- (2) The cost of maintenance of the small crane was excessive.
- (3) When the crane broke down, sampling was impossible.
- (4) The location of the lab was far from the sugar mill main building.
- (5) The administration had been considering hauling cane in the following crop (prior to 1968) during 12 hours only. This would have called for the same amount of analysis in 12 hours formerly done in 24 hours, which was almost impossible without increasing personnel.
- (6) The bagasse from the cane crushed at the laboratory mill would have been excessive.

These factors contributed to management's decision to change the system in 1968.

The first project was to transfer the juice laboratory to the main lab at the sugar mill. Juice samples from the crusher were then sent to the lab automatically. This system functioned as follows:

The weigher gives the truck driver a ticket for the cane to be analyzed. The driver delivers the ticket to the operator of the cane-dump station at the time the cane is discharged from the truck. The cane-dump operator follows the load to the second conductor where the ticket is attached to a metal piece which in turn is tied to a cable moving in the same direction and at the same speed as the cane conductor.

At the end of the cane conductor there is a magnetic detector, and when the metal piece with the ticket attached passes in front of the magnet, a switch is activated which produces a signal indicating that the cane has reached the crusher. A trough under the crusher conducts the extracted juice through a strainer and into a small tank. Two small pumps, one a spare, move the filtered juice sample to the raw juice liming tanks, but the line passes through the laboratory where a sample air-valve spigot is activated by a solenoid valve. When this valve is closed the juice continues to the liming tanks.

The magnetic detector closing the circuit on the arrival of the cane at the crusher activates a timer whose function is to allow sufficient time to elapse so that the juice to be analyzed displaces all the former juice in the line. Once the time has elapsed, another switch operates the solenoid valve controlling the extraction of the juice sample in the laboratory. This signal also activates another timer which controls the time the laboratory valve remains open, thus controlling the amount of juice required for analysis. The same signal which opens the valve also activates a printer that prints the sample number corresponding to the cane-ticket number left at the cane conveyor. Juice and number arrive simultaneously; the owner is not identified until days end.

One problem in this system was with the ticket transport. At times the wind blew the ticket off, and at other times the cable slipped on the pulley so that the ticket did not arrive at destination or arrived late, after the cane had been already ground. To eliminate the problem, we made the following changes, which gave satisfactory results:

A switch was connected by a lever, and the lever in turn is actuated by another lever on the axis of the cane conveyor, so that on each revolution of the axis a signal is sent to a pulse counter, which is adjusted for a certain number of impulses or its equivalent of revolution necessary so that the load of cane which had been dumped on the conveyor arrived at the crusher, thus completing the cycle. That is to say that, once the required number of revolutions was reached the "pulse counter" activated a switch which in turn gave off the signal which previously had been given off by the magnetic detector.

To complete the system a push-button was installed in the operating tower of the cane-dump, so that the operator, upon seeing that a load of cane had been dumped on to the conveyor, pushed the button activating the "pulse counter", thus initiating the cycle described above. As many "pulse counters" may be installed as the load capacity of the conveyor. (Three or four truckloads)

BROADCAST VERSUS THE BAND METHOD OF FERTILIZER APPLICATION TO
STUBBLE CANE ON EVERGLADES PEATY MUCK SOIL

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ABSTRACT

Broadcast and band methods of applying phosphorus and potassium to stubble cane were compared. A soil relatively low in these elements was selected for the study to increase the possibility of fertilizer response. Analyses of cane leaves indicated that both application methods were equal in supplying phosphorus and potassium to sugarcane. Highly significant increases in tons of sugar per acre were associated with phosphorus and potassium fertilization, but differences between the two methods of application were not significant.

INTRODUCTION

Since the beginning of the sugarcane industry in southern Florida, the primary method of fertilizing stubble cane has been banding. Though most stubble cane is still fertilized by the band method, a number of growers are now using the broadcast method. Reasons why growers are switching to the broadcast method of fertilizing stubble cane include: even fertilizer distribution, ease of adjusting application rates and reduced time required for the fertilizing operation.

In reviewing the available literature, no work on methods of applying fertilizer to Florida stubble cane was noted; however, on an Everglades peat soil, Forsee (1) increased sweet corn yields as much as 200% with applications of potassium applied broadcast or in bands. Phosphorus applications by both methods increased sweet corn yields up to 100%. There were no significant differences between broadcast and band application. In a later experiment on a well-decomposed Everglades peaty muck soil, band applied phosphorus gave significantly greater yields of sweet corn than the broadcast application (2).

Growth and yield of field corn on an Everglades peaty muck increased significantly when phosphorus was applied to the soil in bands or broadcast (3). Both growth and yield data indicated a slightly better response to phosphorus applications made in bands, but the increases were not statistically superior to phosphorus applied broadcast.

MATERIAL AND METHODS

A well-decomposed Everglades peaty muck soil, low in available phosphorus and potassium, was selected for this study. To increase the possibility of response to phosphorus and potassium in the first stubble crop only micronutrients were added to the soil when sugarcane variety C1 54-312 was planted September 21, 1967. Since cane growth appeared the same for all plots, and this investigation is concerned with methods of stubble cane fertilization, no yield data were collected from the plant cane crop.

Plots were arranged side by side in a paired trial design in an effort to obtain the maximum difference between treatments. There were three treatments in the phosphorus phase and three treatments in the potassium phase all replicated six times. Treatments 1 and 3 were compared to Treatment 2 (zero phosphorus) and Treatments 4 and 6 were compared to Treatment 5 (zero potassium).

The same treatments were applied in both the first and second stubble crops. Fertilizer treatments were as follows:

Phosphorus phase

1. Broadcast - 100 pounds per acre triple superphosphate plus 300 pounds per acre muriate of potash.
2. Banded - 300 pounds per acre muriate of potash.
3. Banded - 100 pounds per acre triple superphosphate plus 300 pounds per acre muriate of potash.

Potassium phase

4. Broadcast - 100 pounds per acre triple superphosphate plus 300 pounds per acre muriate of potash.
5. Banded - 100 pounds per acre triple superphosphate.
6. Banded - 100 pounds per acre triple superphosphate plus 300 pounds per acre muriate of potash.

Data on percent yield 96° sugar, tons of cane and tons of 96° sugar per acre were determined from the center two rows of each four-row, one-fortieth acre plot. Soil and tissue samples collected from the second stubble crop were analyzed for phosphorus and potassium.

RESULTS AND DISCUSSION

During the first stubble growing season cane receiving no phosphorus was considerably shorter (about 2 feet at 8 months of age) than the cane fertilized with phosphorus applied in bands or

broadcast. No other visual differences were noted. Banded and broadcast triple superphosphate had a highly significant adverse effect on percent yield 96° sugar (Table 1). Previous research indicated moderate to high applications of phosphorus to Everglades peat and peaty muck soils tend to reduce sugar yields (unpublished data by the author). Reduced yields in this trial indicate that phosphorus applied by both methods was available to the cane. Highly significant increases in tons of cane and tons of sugar per acre resulted from band and broadcast triple superphosphate. Phosphorus applied by both methods increased millable cane production over 13 tons per acre and sugar production over 1 ton per acre as compared to the control which received no phosphorus.

Potassium applied in bands or broadcast had no significant effect on percent yield of 96° sugar. Band applied potassium significantly increased tons of cane, but did not significantly increase tons of sugar per acre as compared to the controls, which received no potassium. Tons of cane and tons of sugar per acre were highly significantly increased by potassium applied broadcast.

Differences in percent yield, tons of cane or tons of sugar per acre between the broadcast and band methods of applying phosphorus or potassium to the first stubble crop were not significant.

Table 1. First Stubble Yield Data(1)(2)

PHOSPHORUS PHASE			
Treatment Number	% Yield 96° Sugar 1-12-70	Tons Per Acre	
		Cane	96° Sugar
1 (Broadcast)	11.31	47.82	5.41
2 (Zero P)	12.02	34.02	4.08
"t" Obtained	4.35**	10.31**	11.96**
3 (Banded)	11.13	47.43	5.28
2 (Zero P)	12.02	34.02	4.08
"t" Obtained	5.62**	8.63**	5.45**
1 (Broadcast)	11.31	47.82	5.41
3 (Banded)	11.13	47.43	5.28
"t" Obtained	0.60 N.S.	0.34 N.S.	0.84 N.S.
POTASSIUM PHASE			
4 (Broadcast)	11.21	51.43	5.77
5 (Zero K)	11.79	43.99	5.18
"t" Obtained	2.45 N.S.	9.09**	5.82**
6 (Banded)	11.34	50.27	5.71
5 (Zero K)	11.79	43.99	5.18
"t" Obtained	2.41 N.S.	3.27*	2.07 N.S.
4 (Broadcast)	11.21	51.43	5.77
6 (Banded)	11.34	50.27	5.71
"t" Obtained	0.71 N.S.	0.77 N.S.	0.27 N.S.

(1) Average of six replications.

(2) Harvested 1-20-70.

N.S. Not significant.

* Significant at the 5% level.

** Significant at the 1% level.

Broadcast and band applied phosphorus in the second stubble crop reduced the percent yield of 96° sugar significantly and highly significantly, respectively, as compared to zero phosphorus (Table 2). One-hundred pounds per acre of triple superphosphate applied in bands or broadcast caused a highly significant increase in cane tonnage, 19.20 and 18.14 tons per acre, respectively. Tons of sugar per acre also increased highly significantly due to phosphorus applied either in bands or broadcast. Highly significant increases in tons of cane and tons of sugar per acre were obtained when 300 pounds per acre of muriate of potash was applied to the soil by either method of fertilizer distribution as compared to zero potassium.

Differences in percent yield, tons of cane or tons of 96° sugar per acre between band and broadcast applications of phosphorus or potassium in the second stubble crop were not significant.

Leaf tissue phosphorus and potassium were increased about equally over the controls when fertilizer was applied in bands or broadcast (Table 3). Soil test values for acid soluble phosphorus and potassium were similar for both methods of application. The similarity in soil test results between the two methods of fertilizer distribution may be partially due to mechanical cultivation.

CONCLUSION

Highly significant increases in tons of sugar per acre were attributed to phosphorus and potassium supplied in bands or broadcast; differences between the two methods of application were not significant.

Table 2. Second Stubble Yield Data (1)(2).

PHOSPHORUS PHASE			
Treatment Number	% Yield 96° Sugar 12-29-70	Tons Per Acre	
		Cane	96° Sugar
1 (Broadcast)	11.26	39.03	4.39
2 (Zero P)	12.33	20.89	2.58
"t" Obtained	3.05*	5.87**	6.12**
3 (Banded)	11.52	40.09	4.62
2 (Zero P)	12.33	20.89	2.58
"t" Obtained	4.07**	14.29**	11.80**
1 (Broadcast)	11.26	39.03	4.39
3 (Banded)	11.52	40.09	4.62
"t" Obtained	0.62 N.S.	0.47 N.S.	1.19 N.S.

POTASSIUM PHASE			
4 (Broadcast)	11.30	40.50	4.57
5 (Zero K)	11.82	29.56	3.50
"t" Obtained	4.56**	4.89**	4.47**
6 (Banded)	11.21	38.93	4.37
5 (Zero K)	11.82	29.56	3.50
"t" Obtained	2.53 N.S.	8.05**	4.98**
4 (Broadcast)	11.30	40.50	4.57
6 (Banded)	11.21	38.93	4.37
"t" Obtained	0.33 N.S.	0.68 N.S.	0.81 N.S.

(1) Average of six replications.

(2) Harvested 1-5-71.

N.S. Not significant.

* Significant at the 5% level.

** Significant at the 1% level.

Table 3. Tissue and Soil Analysis Data.

Treatment Number	Treatment	Average of Six Replications	
		Percent Phosphorus in Tissue (1)	Pounds Phosphorus Per Acre 18" Depth (2)(3)
2	Zero Phosphorus (Control)	.15	8.0
3	100 Pounds Per Acre Triple Superphosphate (Band)	.21	14.2
1	100 Pounds Per Acre Triple Superphosphate (Broadcast)	.205	15.5
		Percent Potassium in Tissue(1)	Pounds Potassium Per Acre 18" Depth (2)(3)
5	Zero Potassium (Control)	.65	100
6	300 Pounds Per Acre Muriate of Potash (Band)	1.07	167
4	300 Pounds Per Acre Muriate of Potash (Broadcast)	1.04	178

(1) Tissue samples from the second stubble crop were collected 6-18-70. The third open leaf, with the midrib removed, was analyzed. The results are reported on an oven dry basis.

(2) Soil samples were taken between the row on 1-25-71, 10 months after second stubble fertilization. Potassium was extracted from the soil with .5 N acetic acid, and phosphorus was extracted with .03 N ammonium fluoride .1 N hydrochloric acid, Brays extracting solution.

(3) Prior to planting, the soil contained 10 and 110 pounds per acre of available phosphorus and potassium, respectively.

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EXPERIMENTAL CUSH-CUSH SCREW PRESS OPERATION AT BRYANT

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ABSTRACT

A general discussion of the installation, use, and results obtained at Bryant Sugar House in the application of a French Oil Mill Machinery Company screw press to handle cush-cush. The cush-cush screw press operated for about one-third of the 1970-1971 crop; therefore, an evaluation of results obtained would be somewhat premature. Nevertheless, although no noticeable lowering of sucrose in final bagasse was detected, a significant improvement in the ability of the mills to grind certain canes with high pith to fiber ratios was evident.

INTRODUCTION

Many people have asked us our purpose in using a screw press to handle our cush-cush.

At Bryant Sugar House, we grind a number of varieties of cane that produce a large amount of cush-cush with a fiber composition that is such that our grinding rate is greatly reduced when these varieties go to the mill. In order to obtain an idea of the amount of cush-cush circulating in our cush-cush system, a test was carried out. The figure obtained, as can be seen in Table 1, was 58.20 tons per hour with 80% moisture, or 5.33 tons of fiber per hour. The grinding rate during the test was 385.84 tons per hour, or, with a fiber percent cane of 11%, 42.33 tons of fiber per hour. Thus, in terms of fiber, the recirculated cush-cush amounted to 12.59% of the cane ground.

For the 1968-1969 crop, a three-stage, Model E-99, French Oil Mill Machinery Company screw press was installed on a provisional basis and put into operation. The results obtained with this original installation were completely unsatisfactory. The press was sent back to the manufacturer for modifications, which included enlarging the feed opening and increasing the diameter of the press while converting it from three stages to two stages.

Due to major work on the milling tandem, we were unable to install the press for the 1969-1970 crop.

For the 1970-1971 crop, a permanent installation was made, and the machine was put into operation soon after the beginning of the crop.

EQUIPMENT

This equipment is a Model E-99 cush-cush screw press manufactured by the French Oil Mill Machinery Company. It is a two-stage, electrically driven unit with overall dimensions of 24 feet 6 inches long by 5 feet 6 inches wide. The driver part consists of two motors; the feed stage motor is a 100 Hp, 1800 RPM motor, and the screw stage is a 300 Hp, 1800 RPM motor.

Other equipment fabricated by us, and necessary for the installation, was a 30 inches wide by 40 feet long slat conveyor, a 16 inches diameter by 10 feet long screw conveyor, and an 18 inches diameter by 20 feet long screw conveyor.

INSTALLATION

The crusher, and mills Nos. 1 and 2 send their juice to cush-cush conveyor C. 1, and mills Nos. 3, 4, 5 and 6 send their juice to cush-cush conveyor C. 2.

Without the screw press in operation, cush-cush conveyor C. 1 discharges into mill No. 1 through screw conveyor S. 1, and cush-cush conveyor C. 2 discharges into mill No. 2 through screw conveyor S. 2.

With the screw press in operation, gate No. 2 is open and cush-cush conveyor C. 2 discharges into cush-cush conveyor C. 1. By opening gate No. 1, cush-cush from C. 1 and C. 2 is discharged into cush-cush conveyor C. 3, which feeds the screw press through screw conveyor S. 3. The dry bagacillo is discharged from the press to mill No. 3 through screw conveyor S. 4. See Figure 1.

This gives us a very flexible installation, since the screw press can be put into or taken out of operation without disturbing the operation of the mills.

During the next crop, the juice coming from the press will be screened through a D.S.M. screen and sent directly to the mixed juice tank.

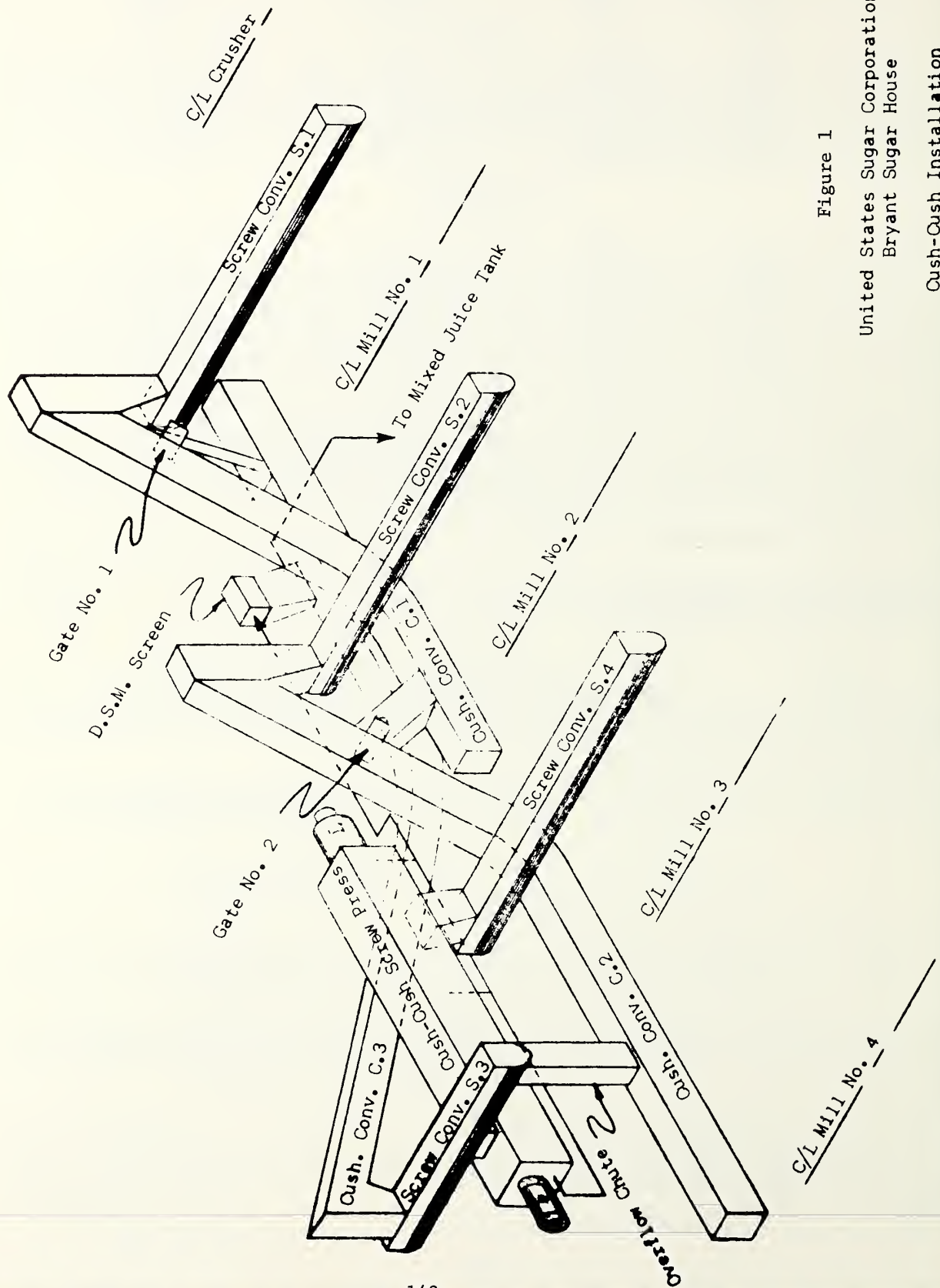


Figure 1

United States Sugar Corporation
Bryant Sugar House

Cush-Oush Installation

RESULTS

This past crop, the cush-cush press was finally put into operation and proved to be very useful with certain varieties of cane, but for reasons explained later, it operated for a total of only 30 complete days.

The sucrose and moisture contents of the bagasse coming out of the press were satisfactory, as can be seen in Table 2. Averages of 5.82% sucrose and 63.53% moisture were obtained.

Unfortunately, after installing the screw press, we had to send the press juice to the mixed juice tank because it was too rich for maceration purposes (Table 3). This incorporated large amounts of very fine bagacillo too small to be screened in our cush-cush drag. The bagacillo stayed in suspension in the clarified juice, causing this station to slow down, and consequently, our grinding rate was slowed also. We made several runs, with and without the press, and came to the conclusion that the juice of the press was the cause of this problem. This is the reason we operated the press for such a relatively short time.

After further experimentation, we found that it will take a 40 mesh screen to clean this juice, and for this coming crop, we have already installed a D.S.M. 40 mesh screen strictly for the purpose of processing the press juice. Hopefully, this will take care of the problem.

CONCLUSION

It is somewhat premature with only about one-third of a crop of actual operation to make an evaluation of the Bryant cush-cush press, but the following observations may be made:

- (a) A significant improvement in the ability of the mills to grind certain canes with high pith to fiber ratios was noticed. These canes, which normally caused a drop in grinding rate of as much as 30% when compared to variety CL 41-223, caused, instead, a drop averaging only 15% -- a net 15% increase.
- (b) No noticeable lowering of sucrose in final bagasse was detected while the press was in operation, nor was there any change in the moisture in bagasse.
- (c) No noticeable increase in grinding rate was detected while grinding CL 41-223, which still represents about 60% of the cane ground by the United States Sugar Corporation.

Table 1. Cush-Cush Conveyor Test

Cush-Cush Conveyor Speed: 97 slats per minute

Weight of Cush-Cush in One Slat:

<u>Gross</u>	<u>Tare</u>	<u>Net</u>
27 lbs.	7 lbs.	20 lbs.

Amount of Cush-Cush.

$$20 \times 97 \times 60 = 116,400 \text{ lbs./hr.} = 58.20 \text{ tons/hr.}$$

<u>Analyses:</u>	<u>Brix</u>	<u>Sucrose</u>	<u>Purity</u>	<u>Moisture</u>
Juice	12.73	10.24	80.44	-
Bagasse	11.00	8.85	-	80.00

$$\text{Fiber} = 100 - (\text{Moist.} + \text{Brix})$$

$$\text{Fiber} = 100 - (80.00 + 11.00) = 9.00\%$$

$$\text{Fiber (Direct Analysis)} = 9.10\%$$

Amount of Fiber: $58.20 \times .09 = 5.33 \text{ tons of fiber/hr.}$

Cane Ground: 9,236.16 tons Time Lost: None

Amount of Cane:

$$\frac{9,236.16}{24} = 384.84 \text{ tons/hr.}$$

Amount of Fiber % Cane at 11.00%:

$$\frac{384.84 \times 11.00}{100} = 42.33 \text{ tons of fiber/hr.}$$

Fiber from Cush-Cush % of Total Fiber:

$$\frac{(5.33)}{100(42.33)} = 12.59\%$$

Table 2. Bagasse Analyses Averages. Bryant Cush-Cush Screw Press. 1970-1971 crop.

Date	Sucrose Average	Moisture Average
12-12-70	5.14	60.17
12-13-70	5.92	64.33
12-14-70	6.20	61.33
12-15-70	5.24	63.66
12-16-70	5.70	63.58
12-17-70	5.74	62.42
12-18-70	5.93	62.17
12-19-70	6.30	69.33
12-20-70	5.93	62.25
12-21-70	5.93	63.42
12-22-70	5.88	63.42
12-23-70	5.83	63.67
12-28-70	5.79	64.17
12-29-70	6.02	64.67
12-30-70	6.20	63.67
1- 1-71	6.66	64.17
1- 2-71	6.11	63.68
1- 3-71	5.05	63.50
1- 9-71	4.73	61.33
1-14-71	5.88	64.00
1-16-71	5.56	64.33
1-17-71	6.25	63.53
1-18-71	5.60	64.67
1-19-71	5.70	64.33
1-20-71	5.65	64.08
1-21-71	6.02	64.67
1-23-71	5.69	62.00
1-24-71	5.51	62.75
1-25-71	6.15	65.00
1-29-71	6.29	61.50
	174.60	1,905.82

$$\text{Sucrose Average: } \frac{174.60}{30} = 5.82$$

$$\text{Moisture Average: } \frac{1,905.82}{30} = 63.53$$

Table 3. Comparative Juice Analyses Averages. Bryant Cush-Cush Screw Press. 1970-1971 Crop.

	Brix Average	Sucrose Average	Purity Average
Crusher	19.36	17.18	88.74
Mill No. 2	16.37	13.79	84.24
Mill No. 3	12.97	10.45	80.57
Cush-Cush Screw Press Outlet A	14.71	12.30	83.62
Cush-Cush Screw Press Outlet B	15.05	12.69	84.32
Cush-Cush Screw Press Outlet C	12.35	10.22	82.75

USDA SUGARCANE SELECTION PROGRAM IN FLORIDA

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Plant Science Research Division
U. S. Department of Agriculture
Agricultural Research Service
Canal Point, Florida

The availability of sexual seed is a prerequisite of any selection program. A yearly average of approximately 290,000 seed was produced for the Florida breeding program during the past 8 years (Table 1). Prior to the construction of the large plastic crossing house in 1960, seed production was erratic at Canal Point because of cold weather that often caused male and female sterility (1).

Early in the variety program at Canal Point, seedlings were grown at 4 locations: Fellsmere, Everglades Experiment Station, Sugarcane Growers Cooperative of Florida, and U. S. Sugarcane Field Station (5). The different locations permitted selection in the environment where the variety was to be grown. Seedlings were often hunch-planted because of a scarcity of land. Selections made from seedlings were planted in 3-foot plots in line tests; the next stage was 3-row plots 20 feet long. The best clones in these tests were advanced to replicated tests at from 1 to 3 locations. Later changes in the variety program have been presented by James and Rice (4) and by Falgout, James and Rice (2).

CURRENT VARIETY PROGRAM

The variety program is a cooperative effort by the U. S. Sugarcane Field Station, Agricultural Research and Education Center of the University of Florida at Belle Glade, and the Florida Sugar Cane League, Inc.

SEEDLINGS

The fuzz is removed from the deep-freeze or taken directly from the crossing house and placed overnight in a forced-air dryer at 105°F. The proper amount of fuzz, as indicated by prior germination test, is weighed out and planted to give approximately 200 seedlings per flat. The fuzz is planted the first week of February. It is spread on methyl-bromide fumigated muck in 21 1/2" x 15 1/2" x 2 1/2" asphalt-coated metal flats. A thin layer of finely-screened muck is spread over the fuzz and the flats are kept moist until the seed germination. The seedlings are clipped weekly to a height of 6 to 8 inches to produce a sturdier plant for transplanting. Seedlings are transplanted as soon after April 15 as possible, usually when they are 10 to 12 weeks old. They are pulled individually from the flats and transplanted to a previously irrigated field. Seedlings are set 12 to 18 inches apart in the row in rows 5 feet apart. They are irrigated again immediately after transplanting and as needed thereafter until they become well established.

The number of seedlings per year grown at the U. S. Sugarcane Field Station at Canal Point has averaged 62,684 during the past 8 years (Table 2). This year there were about 63,000 seedlings planted in the commercial-seedling program, a number approximately equal to the average for recent years.

Seedlings are now being selected in September or October when they are about 8 to 9 months old. A plant-cane selection cycle is being followed. Experimental evidence indicated that in Florida there was no advantage to selecting for Brix, stalk number, and stalk diameter in stubble seedlings (3). Prior to 1970 only 4.2% of the seedlings were selected and advanced to Stage I plots (Table 2). In 1970 we selected 13.6% of the seedlings and we hope to maintain the selection percentage at about 10 to 12%. Growing the same number of seedlings and doubling the selection rate will double the number of clones in Stage I.

Selection in seedlings is based on the following criteria: vigor, stalk number, stalk diameter, stalk length, solidness of the stalk, and freedom from diseases, cracks, and protruding buds. A single stalk is cut from each seedling selected. Selections within a progeny are grouped in bundles of 10 and identified by cross number (e.g. 70-435). The 70 indicates the year the cross was made and the 435 indicates the number of the cross during that year.

STAGE I

Stage I plots are 4 feet long, in rows 5 feet apart. Selections are spaced two feet apart within the row to avoid mixtures. All of the selections from a given cross are grouped and planted continuously until all are planted. Every twentieth plot is planted with the check variety, CP 63-588. There was an average of 3,079 Stage I plots in the last 8 years (Table 3). An average of 5.3% of the clones were advanced from Stage I to Stage II. This past season there were 4,753 Stage I plots and 12% were advanced to Stage II.

Selection in the Stage I plots is made approximately 1 year after planting (September). Selection criteria are: vigor, stalk diameter, stalk number, stalk length, solidness of stalk, stalk weight, length of top, and freedom from diseases.

Clones are selected in the Stage I plots and advanced to Stage II are assigned permanent numbers (e.g. CP 71-1053). The 71 indicates the year the number was assigned and the 1053 indicates the selection number within the year. We start with selection number 1000 each year to avoid duplication of numbers, Louisiana State University assigns numbers 1-299, the Houma Station assigns numbers 300-999, and the Belle Glade Station starts at 2000. When assigned a CP number, the parentage, cross number, number of stalks, and barrel size are recorded on the permanent record sheet for that clone. Juice samples are collected from 5 stalks of each selection in a Hawaiian punch and the Brix content measured with a hand refractometer in the last week of October. The Brix values are recorded on the permanent record sheets. The most promising selections based on agronomic type, Brix, and stalk number are planted at a cold-land location, Sucrose Growers, about 15 miles southeast of Lake Okeechobee in November.

STAGE II

Selections advanced to Stage II plots on the Canal Point Station are planted in two-row plots 22 feet long, (10' x 22'). On the cold land they are planted in two-row plots 15 feet long (10' x 15'). The warm-land location is observed in plant cane only, but the cold-land location is observed through second stubble to measure the stubbling ability of the clones.

The average number of clones in Stage II before 1970 was 137, but in the past season there were 572 clones in Stage II (Table 4). The percentage of clones selected from the Stage II to be advanced to Stage III in the same years averaged 33.5%.

Selection criteria in Stage II are more objective than in earlier stages. A 10-stalk sample is taken and milled. From this sample the following characteristics are obtained: stalk weight, % juice extraction, Brix, sucrose, purity, and sugar per ton of cane (assuming a variety correction factor of 1.00). The number of stalks per plot is counted and estimates of cane yield and sugar per acre are obtained by multiplying the appropriate factors. Clones in Stage II are screened for eye-spot (Helminthosporium sacchari) susceptibility using the Hawaiian technique of injecting eye-spot toxin into the plant. The pathologist also examines these clones at least 3 times per year for symptoms of diseases.

Clones imported for use in the Louisiana breeding program or as a part of the World Collection are another source of clones for Stage II. All new clones imported to Canal Point are grown on the muck and evaluated in the same manner as the ones in Stage I plots. Agronomically acceptable clones are introduced into the regular Florida testing program in Stage II. An example of the importance of testing imported clones is shown by the release of L 61-49 and CP 63-306 this year. L 61-49 was tested in Louisiana but was not released there. It was sent to Florida as a breeding clone, looked good in the breeding plots, and was tested and released. CP 63-306 was imported from Louisiana as a selection to be evaluated in the Florida program. Although neither of these clones was released where selected, we feel they will be of use to the Florida industry.

STAGE III

This is the first replicated stage in the variety program. Each clone is grown in 2-row plots (10' x 15') with 2 replications at each of 7 locations (6 cold land and 1 warm land) throughout the cane-producing area (Figure 1).

The number of clones in Stage III has remained relatively constant over the past 8 years with an average of 49 being planted each year (Table 5). Therefore in any given year there are approximately 100 clones in Stage III considering the plant-cane and first-stubble crops.

Clones in Stage III are again evaluated for: stalk weight, stalk number, Brix, sucrose, and purity. Sugar per ton, cane yield, and sugar per acre are estimated. The data on these clones are summarized and presented to the Variety Committee of the Florida Sugar Cane League, Inc. The committee decides which clones look promising and they are exchanged with the Agricultural Research and Education Center at Belle Glade. Promising selections from Belle Glade are exchanged and planted in our Stage III plots.

All clones that were exchanged are screened for resistance to sugarcane mosaic virus and leaf scald (Xanthomonas vasculorum) during the summer following the exchange and susceptible varieties are dropped from the program. Natural infections are used in screening for resistance to ring spot (Leptosphaeria sacchari), brown strip (Helminthosporium stenopilum), and pokkah boeng (Fusarium moniliforme).

Data are collected on the first stubble of the clones from Canal Point and on plant cane of the ones from Agricultural Research and Education Center at Belle Glade. The same selection criteria are used in first stubble as were used in plant cane with the additional data on stubbling ability. These data are then presented to the Variety Committee which decides which clones are to be advanced to Stage IV.

STAGE IV

Clones advanced to this stage are potential varieties for release to the industry. Seven test fields as shown in Figure 1 are operated by the Canal Point Station. One test field is located on each of the following 7 farms: (1) Lykes Bros., (2) A. F. Saunders, Inc., (3) Beardsley, (4) Gulf and Western Food Products Co. at Okeelanta, (5) Wedgworth Farms, Inc., (6) Hatton Bros., Inc., (7) Sucrose Growers. Four replications, each 20' x 35', are planted at all locations. Data are taken on these tests in the plant-cane, first-, and second-stubble crops. Samples are taken from the weighed cane and processed through the sample mill at Canal Point to determine stalk weight, Brix, sucrose, purity, fiber, and sugar per ton. Complete milling tests giving the % extraction, sucrose reduction factors, and varietal correction factors are conducted on varieties in Stage III or Stage IV. The entire cane per plot is weighed in each of the 3 crops and these weights are used to calculate sugar per acre. Two check varieties, Cl 41-223 and CP 63-588, are included in these tests.

The varieties included in Stage IV are tested simultaneously by USDA and personnel at the Agricultural Research and Education Center at Belle Glade. After plant-cane data have been obtained from the replicated test the variety committee may recommend that promising varieties be extended under the supervision of the Florida Sugar Cane League, Inc. so that adequate supplies of seedcane will be available at the time of release. A variety is considered for release when second-stubble data has been collected and at this point a variety is either discarded or recommended for release by the cooperating agencies, USDA, University of Florida, and Florida Sugar Cane League. The number of varieties planted in Stage IV tests and the number of varieties released to the industry between 1963 and 1970 are presented in Table 6.

Seedcane distribution on newly-released varieties is handled by the Florida Sugar Cane League, Inc. If there are more requests for seedcane than is available from the 80% that cooperators agree to sell, then the amount allotted to a farm is based on its proportionate share acres.

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Table 1. Sugarcane seed produced for the Florida breeding program

Year	Estimated number seed
1963	127,404
1964	27,609
1965	617,083
1966	526,533
1967	481,029
1968	180,436
1969	71,574
1970	290,431
Ave.	290,262

Table 2. The number of seedlings in USDA variety program at Canal Point.

Year	Number seedlings	Selection percent
1963	27,294	.014
1964	56,950	.044
1965	48,909	.035
1966	74,401	.030
1967	90,197	.054
1968	102,413	.034
1969	66,275	.071
1970	35,040	.136
1971	63,000	-
Ave.	62,684	.049

Table 3. The number of Stage I plots (4' x 5') at Canal Point.

Year	Number	Selection Percent
1963	383	-
1964	2,506	.073
1965	1,728	.048
1966	2,263	.052
1967	4,857	.022
1968	3,466	.054
1969	4,683	.030
1970	4,753	.120
Ave.	3,079	.057

Table 4. The number of Stage II plots (10' x 22' and 10' x 15') in the USDA sugarcane variety program.

Year	Number	Selection percent
1964	183	.224
1965	83	.301
1966	117	.462
1967	108	.352
1968	188	*
1969	141	.340
1970**	572	-
1970***	153	-
Ave.	174	-

* No clones advanced due to leaf scald quarantine.

** Warm land.

*** Cold land.

Table 5. The number of Stage III clones between 1963 and 1970.

Year	Number	Selection percent
1963	61	.066
1964	41	.220
1965	25	.440
1966	54	.185
1967	38	.263
1968	*	*
1969	48	-
1969**	2	-
1970	52	-
1970**	7	-

* No Stage III plots planted because of leaf scald quarantine.

** Belle Glade selections.

Table 6. The number of clones planted in Stage IV and varieties released between 1963 and 1970.

Year	Number	Varieties released
1963	5	0
1964	10	0
1965	12	0
1966	12	1
1967	12	3
1968	9	3
1969	9	1
1970	9*	0

* Released varieties.

THE EFFECTS OF LATE MOWING ON FROSTED SUGARCANE IN FLORIDA

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ABSTRACT

Mowing frozen plant cane of variety CP 57-603 after fully developed internodes were formed in early April retarded maturity in samples taken in December, resulted in more but lighter stalks, and reduced cane yields at harvest in March. Cane from plots that were not mowed produced 13 percent more sugar per ton of cane in December. When the cane was harvested in March unmowed plots yielded 10 percent more cane and 14 percent more sugar per acre than the mowed plots.

A large percentage of the sugarcane in Florida is grown in colder areas away from the protective influence of Lake Okeechobee. Late summer- or fall-planted cane is often frosted back and the grower is confronted with the question of whether to mow off the dead sugarcane tissue or to leave it undisturbed.

Research in Florida, Louisiana, and South Africa showed that mowing sugarcane which had been killed by late freezes reduced yields of cane and sugar per acre and was thus uneconomical (1, 2, 3, 4). Since the question of mowing is still important in Florida, an experiment was designed to test the effect of mowing late frosted or frozen plant cane on plant survival, rate of elongation, juice quality and cane production.

EXPERIMENTAL METHODS

A field of CP 57-603 that had been planted in August 1969 and was in advanced stages of development with several formed internodes was severely frosted on January 11, 1970. The field is located on 715 Farms, Ltd. near Pahokee, Florida, approximately 1 1/4 miles from the southeast shore of Lake Okeechobee. The field was observed frequently and little growth and recovery was noted although the plants were green several inches above the ground. On April 2, a large tractor-drawn rotary mower was used to mow alternate 4-row strips throughout the entire field. The growing plants were mowed 2 to 3 inches above the ground to avoid damaging the stubble. Five 100-foot 4-row plots of mowed and unmowed cane were selected from a representative section of the field. A 50-foot buffer zone was left at each end of the 100-foot plots.

On April 29, 1970, 10 representative tillers or shoots from each treatment were tagged, and a base-measuring stake placed at each selected tiller. Growth measurements were taken at 2-week intervals from May 13 to August 19, 1970.

Lateral shoots, or lalas, often develop from lateral buds after the terminal bud is damaged. This condition is especially important when most of the terminals are killed by freezing temperatures. There has been considerable speculation as to whether the lalas eventually die or develop into mature stalks. On June 10, 1970, 100 lalas from each treatment were tagged and counted at varying intervals beginning on June 24 and ending on August 5.

On December 10, 1970, 10 stalks were cut at random from each replication (five samples from each treatment) to determine the effect of mowing on maturity of the stalks. The cane in all the plots was cut by hand on March 10, 1971 and weighed with a tractor-mounted weighing device. Two 15-stalk samples were taken from each replication (10 samples from each treatment) and transported to the Canal Point laboratory for weighing, milling, and analyzing the crusher juice. The indicated yields of sugar per ton of cane were determined for early harvest, December 10, and for late harvest, March 10. The actual yield of cane per acre was obtained for the late harvest date by weighing all the hand-cut cane in each plot. The yield of cane for December 10 when only mill samples were taken was assumed to be the same as the yield obtained on March 10. The yield of sugar per acre for each date was obtained by multiplying the indicated yield of sugar per ton of cane by the yield of cane per acre. The data were analyzed statistically, using paired observations.

RESULTS

The mowed cane grew more rapidly than the unmowed cane during the first month (Figure 1). From June 1 to August 19 when growth measurements were discontinued, and for the period as a whole the unmowed cane grew more rapidly than the mowed cane.

Table 1 gives survival of lalas from mowed and unmowed plots. The mortality rate of both treatments was equal at the end of the first 2-week period, however at the end of 8 weeks only 16 percent of the lalas from mowed plots were living as compared to 36 percent for those in unmowed plots.

The unmowed plots averaged nearly 6 tons more cane per acre than the mowed plots when the cane was harvested on March 10, 1971 (Table 2). Yields of sugar per ton of cane were slightly higher in the unmowed plots on both sampling dates, December 10, 1970 and March 10, 1971. The unmowed plots averaged 1,638 more pounds of sugar per acre than the mowed plots at the time of harvest. The yields of cane and sugar per acre are statistically significant but the yields of sugar per ton are not significant. The average weight per stalk was higher in the unmowed plots than those in the mowed plots on both sampling dates.

DISCUSSION OF RESULTS

The question of whether frozen cane in advanced stages of growth should be cut and removed from the stubble will probably never be answered. During some years when a killing freeze occurs in January or February, cane that was planted in August or early September may have several full-size internodes. Killing of the terminal buds, or meri-stems, arrests the growth of those shoots, resulting in the development of lateral buds and shoots or lalas. Cane farmers do not like the appearance of the frozen cane and believe that the laterals or lalas will not produce millable stalks. In our experiment the new growth elongated more rapidly immediately after having been mowed and for a month thereafter. The unmowed cane actually grew more rapidly during the remainder of the season and for the season as a whole. The mowed cane was retarded as evidenced by juices of lower sucrose and purity and by reduced yields of cane per acre. Although there were more stalks per acre in the mowed plots they were lighter and, consequently, yielded less total cane per acre.

The survival of lateral shoots or lalas was greater in the unmowed plots than in the mowed plots. It might be pointed out that even in the mowed plots a substantial length (2 to 3 inches) of shoot remained above the ground permitting laterals to develop above the ground.

It is recognized that we mowed the cane in our experiments much later than we should have. Much green tissue was cut when the cane was mowed. On the other hand some cane in commercial fields was still being mowed at the time our experiment was mowed on April 2 so results of this study are conformable to commercial field practices.

Earlier mowing would no doubt result in less apparent damage to the cane if it was done after a freeze. If the cane is cut a few days before a freeze and growing rapidly when frozen, it would be much more susceptible to permanent damage. It is therefore concluded that mowing frozen cane is a gamble at best and should, under no circumstances, be done late in the season.

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Table 1. Survival of 100 shoots (lalas) in mowed and unmowed plots from June 10 to August 5, 1970.

Date of count	Mowed	Unmowed
	Number	Number
June 10, 1970	100	100
June 24, 1970	98	98
July 22, 1970	21	42
August 5, 1970	16	36

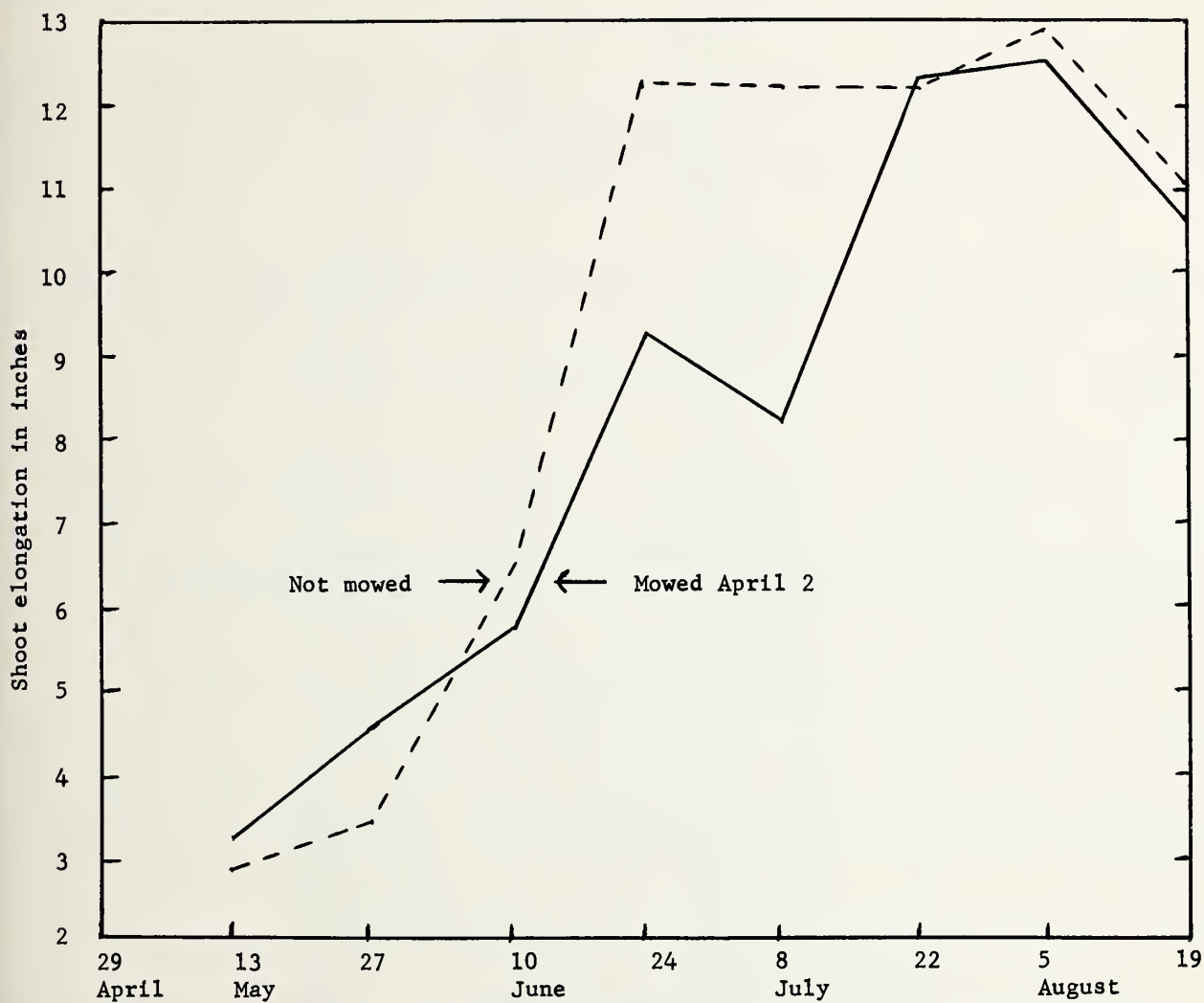


Figure 1. Average growth of mowed and unmowed shoots by bi-weekly periods from April 29 to August 19, 1970.

Table 2. Results of mowing experiment with C.P. 57-603 plant cane in Florida during the 1970-71 season.

	Yield of cane per acre		Indicated yield of 96° sugar				Average weight per stalk	
			Per ton of cane		Per acre			
	Dec. 10 ¹ /	Mar. 10	Dec. 10	Mar. 10	Dec. 10 ¹ /	Mar. 10	Dec. 10	Mar. 10
	Tons	Tons	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Unmowed	63.63	63.63	158.1	216.2	10,066	13,757	4.1	5.6
Mowed	57.71	57.71	139.7	210.0	8,062	12,119	3.8	4.8

^{1/} Estimate based on assumption that yield of cane per acre in December is equal to yield at harvest.

Differences between yields of cane and sugar per acre are statistically significant at 5% level. Yields of sugar per ton are not significantly different.

RAT CONTROL IN FLORIDA SUGAR CANE FIELDS

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INTRODUCTION

Rats have been a major pest of sugar cane in Florida throughout the history of the industry. Recent surveys have estimated our annual losses to be between \$2 and \$3 million, (1) In June 1967, the Florida Sugar Cane League began investigating the problem in an attempt to reduce these losses. This report is intended to emphasize those aspects of the rodent problem which make it complex and difficult to solve.

SPECIES CHARACTERISTICS

Four species of rats have been collected from Florida sugar cane fields where damage has occurred. Prior to 1960 the cotton rat, Sigmodon hispidus, was the most abundant species and was considered to be the number one rat problem. The rice rat, Oryzomys palustris, was considered second in importance and population standings. Both of these rats do very little burrowing but are often found in burrows that have been abandoned by other animals. One percent zinc phosphide baits are very effective in controlling both cotton and rice rats and its use since the 1940's has undoubtedly helped cause the recent decline in importance of these two species.

The roof rat, Rattus rattus, was described (2) as a pest of sugar cane in Florida. This rat was observed in the cane area prior to 1960 by various researchers whose unpublished reports suggested that it might become a serious pest in some cane areas. Today the roof rat occurs throughout most of the cane belt and is a major pest.

This rat damages cane stalks usually between 2 and 5 feet above the ground. Damage to this area of an erect stalk is fairly characteristic of this rat. Some burrowing is done which may provide nesting areas.

The zinc phosphide baits that give good control of cotton and rice rats do not work as well against the roof rat, which may help explain its increase in numbers and importance.

The fourth species which damages cane is the Florida water rat, Neofiber alleni True, also called the round-tailed muskrat or Everglades water rat. It has existed in Florida since its discovery in Brevard County in 1883 (5). Madsen (2) reported "relative low numbers" of N. alleni in the "general" sugar cane areas around Lake Okeechobee. It was not considered a major pest of sugar cane at that time.

True (5) described the Florida water rat as "a living link between the muskrat and the field mouse". It weighs less than one pound, has a medium length tail, a large head and small inconspicuous ears. It also has small beady eyes, large incisors, and claws adapted for digging. The fur is shiny black with long, coarse guard hairs. It looks more like a guinea pig than a field rat.

Birkenholz (1) described the life history and ecology of the Florida water rat from a location in North-Central Florida. Prairies, ponds and sloughs were characteristic of his study area which appeared to have undisturbed, native vegetation. These conditions are quite different from those in sugar cane fields and may explain why the houses, feeding platforms, and feeding shelters described by Birkenholz are rarely seen in the sugar cane area.

The average offspring per litter is two, with four or five litters per year (1). This reproductive potential is far below that of the other rat species which occur in the area.

The homesite of the Florida water rat consists of very extensive and elaborate burrow systems in the deep, rich muck soils of the sugar cane fields. Many of the burrows are on ditchbanks at the field edges while others may be in the middle of the field over one hundred yards from the nearest ditch. The large, fan-shaped mound of soil at many burrow entrances is very characteristic of this species in this area. It apparently feeds to some extent on roots and therefore is digging continually and extending its burrow. These burrows are often dug directly beneath the sugar cane, injuring the root system and often killing the plant, thus causing losses for several years until the field is replanted. One burrow system may have 36 or more openings and be fifty yards or more in length.

Along with causing root damage the Florida water rat damages the sugar cane stalks. This is the most common type of rodent damage which is also caused by the other rat species.

The degree of damage caused by the Florida water rat cannot be easily calculated because of the presence of the three other rat species. These often inhabit abandoned Florida water rat burrows and confuse the observer.

All efforts to control this pest have been unsuccessful, including the use of anticoagulants and zinc phosphide baits. Because of its limited activity above ground the Florida water rat is not usually exposed to bait stations placed around field perimeters. Most baits are not acceptable to this rat, even when hand-placed directly into its burrow. The use of poisonous gases has been ruled out because of the large number of burrow openings and the fact that much of the burrow system is filled with water.

The Florida water rat is a very hardy species which seems to have found a near perfect habitat in the South Florida sugar cane fields. Because of its behavioral characteristics and aversion to poison baits it will probably remain a major pest until new control methods and materials are developed.

LIVE TRAPPING PROCEDURES

Live traps have been used intermittently throughout most of the cane growing area since June 1967, as a survey tool. This not only produced information about what species of rats were present and where each was located, but also provided a supply of animals for cage testing.

The traps were generally set in a field in the afternoon and checked early the next morning. Fresh apple slices were found to be a good bait material which was well accepted by all four species of rats. However, a more convenient bait consisting of oatmeal and water was used much more frequently. A small amount of water was added to a handful of oatmeal flakes and molded until the mixture reached the consistency of putty. It was then easy to form a small amount on the trigger of the traps. The mixture would soon dry and become quite hard.

Good catches of cotton, rice and roof rats were obtained by placing the traps on the surface of the ground. Usually the traps were set close to the edge of a field near fresh damage or burrow openings. This procedure was not very effective for capturing the Florida water rat and special techniques were devised. This rat could be captured best if the traps were set below ground level in a hole dug to intersect the burrow. The trap door had to fit tightly against the burrow opening or the rat would go under or around it. This has proven to be the most successful method for live trapping the Florida water rat.

LABORATORY TESTS

After being trapped, the rats were brought into the laboratory for processing. They were weighed, treated with a pyrethrin dust for fleas, lice, etc., and placed in a clean cage. They were given laboratory chow as a standard diet and a terramycin-water mixture for 3 days to clear up any internal infections. They were then maintained in the cages for 1 to 2 weeks to adapt to the laboratory conditions before any testing was done. These procedures were closely followed so that all test animals would have similar backgrounds before testing which would make comparisons more meaningful.

Most of the test materials were commercially available rodenticide formulations or custom baits used by various growers. Detailed records included the amount of bait consumed, days of treatment, animal weight at death, and general observations during the test. Laboratory chow was always available to the test animals along with the test rodenticide and the position of the two were switched daily to eliminate position preference.

Florida water rats were not included in these tests because they would not survive in the small laboratory cages. They would survive in larger cages, 2' x 3', if a large pan of water was available to them. It required changing daily as the rat spent most of the night eating and swimming in the water.

LABORATORY RESULTS AND DISCUSSION

Table I presents a summary of the laboratory findings. The zinc phosphide baits gave better control of both cotton and rice rats than did the anticoagulants. This is mainly due to the amount of material that was consumed and the time to death. With zinc phosphide the average number of days of feeding before death for cotton rats averaged about one, with the exception of the cane fiber pellet. The days to death required for the anticoagulants ranged up to 25. The results with the rice rat were similar with the cracked corn formulation of zinc phosphide giving the best degree of control.

The roof rat was the most difficult of the three species to control with the compounds tested. The percent control with the zinc phosphide formulations was less than satisfactory, while the anticoagulants required excessive days of feeding. The best results were obtained with a freshly mixed warfarin bait which killed 5 of 6 test animals in an average of 9.8 days.

It was concluded from these tests that zinc phosphide is still a reliable rodenticide for at least 2 of our 4 rat species as a 1.0% bait. Though these formulations of zinc phosphide were unsatisfactory against the roof rat, further testing with 2.0% bait is anticipated. A 1.88% zinc phosphide on crimped oat groats, which has not been tested here, has given good roof rat control in Hawaii.

FIELD TESTS

Several attempts have been made to evaluate rodenticide formulations under field conditions. Thus far all field testing has given mostly inconclusive results because we do not have effective procedures for field evaluations.

Some testing was done where Florida water rats were known to exist. Several bait formulations were hand-placed inside burrow entrances which had signs of recent activity. The following morning most of the baits were outside the burrows, uneaten or only slightly gnawed.

Conclusions that can be drawn from these limited field tests are that:

- (1) The Florida water rat is not being controlled with conventional methods and materials.
- (2) Better methods must be developed for field testing.
- (3) Testing in outdoor pens may provide some answers.

A GOOD RAT CONTROL PROGRAM

The following suggested program to reduce rodent damage results from testing and observations. It is not a simple matter of throwing poison baits around now and then. In order to achieve a good degree of control a conscientious effort is needed.

- (1) Carryout good cultural practices - keep fields and adjacent areas free of excess vegetation. This reduces the carrying capacity of the land by removing habitat necessary for nesting and feeding.
- (2) Protect predators - bobcats, hawks, skunks, snakes, etc. all take their toll of rats.
- (3) Follow a program of baiting at least 3 times a year: soon after harvest, early summer, and fall. Switching from zinc phosphide baits to anticoagulants on alternate treatments will probably provide the best degree of control.
- (4) Zinc phosphide on cracked corn should be applied at the rate of 5-10 lbs/acre to field edges, ditch banks, road ways, etc.
- (5) When using anticoagulant meal baits in bait stations, keep a fresh, constant supply available for at least 3 weeks before moving to another location. Stale, moldy, insect-infested bait will discourage future visits to the stations, which ideally should be no more than 100 feet apart.
- (6) The portions of the field adjacent to ditches should receive the most attention for this is where most of the damage occurs. The middle ditch in a 40 acre field is often the most neglected part and is home for many rats.
- (7) Encourage your neighbors to carry out a control program of some kind as this is an industry-wide problem.

CONCLUSIONS

The rodent problem in Florida is very serious. The annual losses plus the expense of control practices is costing too much. The answer to the problem will not be simple and is not yet in sight. At present we should all do the best job we can with the tools available. Flooding large areas prior to planting may help reduce the problem, or at least delay re-establishment of populations.

The use of fresh vegetable baits such as sliced apples or potatoes coated with zinc phosphide may be useful in treating small areas. This type of bait is difficult to use in control programs covering hundreds or thousands of acres because the prepared baits begin to spoil rapidly.

The Florida water rat is rapidly becoming our number one problem. Hopefully research will provide a method of control that will be effective against it.

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Table I. SUMMARY OF LABORATORY TESTS FOR RAT CONTROL - 1967-70

Bait Carrier	Active Ingredient	Cotton Rat			Rice Rat			Roof Rat			
		# of Rats	Ave. days to death	% killed	# of Rats	Ave. days to death	% killed	# of Rats	Ave. days to death	% killed	
ONE-SHOT POISONS											
Cracked Corn	zinc phosphide	1.0%	28	1.0	89.3	23	1.6	82.6	20	1.4	35.0
Wax Pellet	zinc phosphide	1.0%	17	1.0	82.4	4	9.0	25.0	2	-	0
Scratch Feed	zinc phosphide	1.0%	4	1.0	100.0	4	1.5	50.0	5	2.0	20.0
Pellets	zinc phosphide	1.0%	11	1.0	63.6	4	2.0	25.0	2	7.0	50.0
Cane Fiber Pellets	zinc phosphide	1.0%	7	4.0	14.3	7	-	0	12	3.0	25.0
Pellets	Endrin	1.5%	5	7.0	40.0	6	7.0	16.7	29	8.3	13.8
Pellets	Strychnine	0.62%	3	1.0	33.3	2	-	0	5	-	0
Pellets	Thallium Sulfate	0.5%	2	2.0	100.0	-	-	-	11	-	0
ANTICOAGULANTS											
Corn Meal	Fumarin	0.025%	4	9.3	100.0	8	9.2	62.5	4	23.0	100.0
Pelleted Meal	Pivalyl	0.025%	2	3.5	100.0	-	-	-	2	10.0	50.0
Corn Meal	Fumarin	0.025%	2	15.0	100.0	-	-	-	-	-	-
Pelleted Meal	Pivalyl	0.025%	2	12.4	100.0	5	9.25	80.0	-	-	-
Pelleted Meal	Warfarin	0.025%	4	25.0	100.0	-	-	-	-	-	-
Corn Meal	Warfarin	0.025%	6	9.5	100.0	-	-	-	-	-	-
Bait Block	Diphacinone	0.005%	7	15.6	71.4	5	-	0	6	20.2	83.4
Corn Meal (fresh)	Warfarin	0.025%	5	15.2	100.0	6	18.4	83.4	6	9.8	83.4

NUTRITIONAL DEFICIENCY SYMPTOMS OF SUGARCANE

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ABSTRACT

A nutriculture experiment was conducted in the greenhouse to study the development and distinguishing characteristics of nutrient deficiency symptoms on sugarcane. Five varieties were grown in modified Hoagland's solutions. The solutions included: Complete nutrition, -N, -P, -K, -Ca, -Mg, -S, -Cu, -Mn, -Zn, -B, and -Fe. Deficiency symptoms were recorded by visual observations and photography. Colored slides of these symptoms were presented and discussed in regards to: (1) distinguishing characteristics; (2) development with time; (3) probable effect on crop productivity; (4) field conditions conducive to deficiency; (5) normal and critical leaf tissue and soil test levels; and (6) varietal differences.

THE CHEMISTRY AND USES OF FURFURAL

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ABSTRACT

Furfural is an amber-colored liquid that is known in the Chemical world as an aldehyde. It was developed originally as a solvent and although it has never appeared as table food, fuel or wearing apparel, it is used in the manufacture of those items as well as hundreds of others.

First developed to utilize oat hulls discarded from rolled oats production, it is now derived from other agricultural waste such as corn cobs, cottonseed hulls and rice hulls, as well as from bagasse, a by-product of the sugarcane refining process.

Furfural is now widely used as a selective solvent in the petroleum industry to produce lubricants and raw materials for synthetic rubber, as a resin former, a reactive solvent and a chemical intermediate. Its derivatives, such as furfuryl alcohol, tetrahydrofuran, furan, tetrahydrofurfuryl alcohol and polymers, are used by many other industries, including foundries and the plastic and rubber industries.

Quaker chemical manufacturing plants are located in Memphis, Tennessee; Omaha, Nebraska; Cedar Rapids, Iowa; Belle Glade, Florida; Southall, England, and Antwerp, Belgium.

A REVIEW OF LAND GRADING IN LOUISIANA

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Land grading is a soil and water conservation practice that is expanding throughout the river bottom areas of Louisiana. It had its beginning in the cotton area of Northeast Louisiana and for many years the acceptance of land grading was limited mainly to that area. More recent years have seen it spread to the entire Red River bottom area and to the sugarcane areas in the Mississippi River bottom.

I should define land grading now so we will all be thinking alike. Land grading, in the simplest terms, is reshaping the surface of the land to planned grades. I am going to combine two very similar practices that the Soil Conservation Service is involved in in my discussion. These are Drainage Land Grading and Irrigation Land Leveling. The standards and specifications for both practices are essentially the same. The only difference is the primary purpose for which the practice is installed. Drainage is the primary purpose for Drainage Land Grading and irrigation is the primary purpose for Irrigation Land Leveling. Both purposes can be accomplished with either practice by use of proper planning.

You can see from the title of my presentation that it can cover a broad field. I intend to emphasize land grading as it applies to the sugarcane area. I will need to go back in history some to give a true picture though.

What is the main problem that the row-crop farmer has in Louisiana? I think everyone would answer drainage. Erosion was the big problem thirty years ago when there was still lots of farming in the hill areas of the state.

The first thing that must be available for successful drainage of a farm is an adequate outlet. The Louisiana Department of Public Works and Soil Conservation Service have provided and are providing these outlets throughout the state. Many projects are joint ventures by both agencies.

You are all familiar with the sugarcane drainage pattern composed of farm mains or laterals, cross ditches, and split ditches. Split ditches are parallel with the general land slope and from less than 100 feet apart in heavy clay, poorly drained soils, to approximately 200 feet apart in the better drained sandy soils. Cross ditches are used in lows to intercept water from split ditches or they are used to reduce the length of split ditches.

The intensive system of split ditches virtually insured the early cane farmer of good drainage. Through the use of quarter drains he could get water from any low across to the deep split ditch.

This sugarcane drainage pattern posed no particular problem as long as labor was plentiful and multi-row equipment was non-existent. The advent of the mechanized equipment for split ditch maintenance helped reduce the labor requirement and expense.

The method of split ditch maintenance over the years aggravated the drainage problem. Spoil dirt was deposited along the bank of the split ditch or at best spread over the first two or three rows. After a number of split ditch clean-outs a high bank had developed adjacent to the ditch. This, combined with poor tillage practices in many fields, resulted in low areas in the "cuts" that could not be drained.

The practice of land crowning came upon the scene as an answer to elimination of the lows between "cuts". Crowning is the shaping of an area of land into adjacent, parallel strips greater than sixty feet in width and of any length. This did not eliminate the split ditch. Crowns generally have a peak in the center of the cut and slope to the split ditch on either side. This slope must be at least 0.3 foot per 100 feet.

Crowns have the advantage of being relatively easy to build even with inexperienced equipment operators. There has been a tendency over the years to over-build crowns and this can actually cause an erosion problem because excessively steep slopes on the crowns can result. Decreased yields may result on these over-built crowns in dry years.

Construction equipment was readily available to construct crowns (bulldozers, graders, and motor patrols) when crowning was introduced.

It is recommended that crowning be limited to the low, heavy clay soils. I am not saying crowning is not a good practice in its place. It has improved drainage in the sugarcane area tremendously. I am saying that we have a much better practice available now (land grading) and we should be land grading our better soils instead of crowning.

Land smoothing is another practice that is being used to improve drainage. Land smoothing is removing irregularities on the land surface by use of special equipment, bulldozers, land planes, etc. Overall slope of the land is not changed. End results of land smoothing are to a great extent dependent upon input and existing topographic conditions. Fields should be relatively uniform for this practice to prove satisfactory.

Labor shortage and cost, demand for improved efficiency, and a narrowing gap between cost of production and return demands that further improvements be made in drainage of sugarcane areas. (This is not limited to sugarcane farming). We feel that drainage land grading is the answer. It provides means for improved drainage, efficient operation, increased yields, utilization of more acres of "prime" land, and other benefits.

Land smoothing is the cheapest practice to install, followed by crowning, with land grading being the most expensive. I will say more later on cost of land grading.

I would like to turn more specifically to land grading with a little history of the practice first. As mentioned earlier, land grading started in Northeast Louisiana. The main purpose of this land grading in the early 1950's was for irrigation. More efficient use of irrigation water could be obtained when land had been reshaped to a planned grade. It was soon found profitable for drainage purposes, also.

Approximately 55,000 acres of land in Northeast Louisiana have been land graded with assistance in design, layout and supervision of construction from the Soil Conservation Service. East Carroll Parish leads with 15,000 acres, Morehouse Parish with 13,000 acres, and Tensas and Franklin Parishes with 5,000 acres each.

The question was raised during the middle 1950's as to whether land grading could be used in the sugarcane area successfully. Many of the farmers were highly doubtful saying that ditches were placed too far apart and would not provide adequate drainage. Another factor to be considered was the harvest season. Rain or shine, the cane harvest must go on. A combination of a wet harvest season along with the big heavy harvesting equipment cast dark clouds in many peoples' minds as to the workability of land grading for sugarcane. It was feared that boggy conditions would be created that would be difficult to dry up. Crossing of the drainage field ditches in wet seasons was a major concern.

The Agricultural Research Service with the assistance from the Soil Conservation Service established an experimental plot of land grading in West Baton Rouge Parish in 1956. This plot was on the Catherine Plantation managed at that time by Mr. John Best. The biggest lesson learned from this was that you can grade the land to be too flat when finished.

Land grading had its real beginning in the sugarcane area in the New Roads work area of the Soil Conservation Service (Pointe Coupee and West Baton Rouge Parishes). We had some strong believers in the SCS in this work unit that believed land grading would work in the sugarcane area. It was in the early 1960's before it began to be accepted to any extent in these parishes. There has been approximately 9,600 acres of land graded in the sugarcane area as of July 1, 1970 with SCS assistance. Nearly half of this, 4,500 acres, has been graded in the New Roads work area.

I would like to review with you land grading accomplishments in the sugarcane area during the last five fiscal years and bring out how acceptance of it has begun to spread. I will give it by SCS work unit areas. New Roads remained about constant at 600 to 700 acres per year from FY '66 - '70. There were only two other work units besides New Roads reporting land grading in FY '66 -- New Orleans and Houma. Three other work units besides New Roads report land grading in FY '67 -- Plaquemine, New Orleans, and Donaldsonville. Six other work units besides New Roads reported land grading in FY '68, '69, and '70. Annual accomplishments of land grading in the sugarcane area has steadily increased besides spreading to other parishes. There were 758 acres graded in FY '66, 870 acres in FY '67, 1,047 acres in FY '68, 1,641 acres in FY '69, and 2,467 acres in FY '70.

The most impressive increase in one work area, Houma, was from 87 acres in FY '66, zero acres in FY '67, to 1,026 acres in FY '70. Approximately 600 acres of land grading on sugarcane lands in Avoyelles and Rapides Parishes is not in the above year by year breakdown but it is reflected in the 9,600 acre total. Our reporting system makes it difficult to determine the years this 600 acres was leveled since there is a sizeable acreage of other than sugarcane land being graded in these parishes each year that also appears on the records.

The acreage of land grading is not so impressive when compared to acreage in sugarcane. The significant things to be obtained from a study of these figures is that land grading in the sugarcane area is moving out from a more or less localized area where it began to several other parishes and it is steadily increasing.

Over 75,000 acres of land grading has been installed with SCS design and supervision of installation when considering all crop uses.

I have already mentioned that land grading is reshaping the surface of the land to planned grades. You can, also, visualize the finished job as a tilted plain, usually on one corner. It will have slope parallel with rows, and perpendicular to the rows.

I would like now to review some of the standards, specifications, and installation procedures involved in land grading. First of all, land grading should be done as a part of an existing drainage

system or as a part of a new or revised drainage plan. The area to be graded should have the maximum practical width consistent with the recommended drainage ditch spacing, land capability and topography. Minimum width should be 400 feet unless restricted by permanent fences, roads, property lines, etc. Row drainage should be accomplished by use of drainage field ditches. These ditches normally are about one foot deep with side slopes of five feet horizontal to one foot vertical or flatter. They are placed immediately above the headland. No intermediate cross drainage, such as quarter drains, are needed between headlands or roads.

Land slope in the direction rows run should not exceed 0.5 foot per 100 feet. A slope of 0.1 foot to 0.3 foot is recommended. Cross slope, or slope perpendicular to the rows, should not exceed 0.5 foot per 100 feet.

Complete topographic surveys must be made of areas to be land graded. Stakes are set on 100 foot centers. Ground elevations are determined at these stakes. A design is made balancing cuts and fills throughout the area. Where possible optimum grades for the least soil to be moved are used. If these grades are too flat or steep adjustments must be made.

The ideal minimum size plot to land grade is from approximately 1,000 feet to one-fourth mile long and 800 - 1000 feet wide. Soil type and other conditions may alter this. Plots are normally bordered by a V-lateral or flat bottom lateral 2-4 feet deep parallel with row direction. The shallow drainage field ditch forms the other plot boundary. Where plots can be drained in opposite directions the distance between ditches can be doubled.

A review of a field with the typical sugarcane drainage system before land grading and the drainage system after land grading is needed to properly analyze the benefits to be obtained from land grading. Figure One shows the drainage system before drainage land grading and Figure Two shows the drainage system after land grading. There were 4.2 miles of ditches eliminated by land grading this area. This, plus the elimination of headlands and all quarter drains brought 4.7 acres of land into production and increased the productive land in the area by 7.7 percent. The additional land brought into production as a result of land grading will vary but it will generally be between 5 and 15 percent.

Most of the land grading is being done on sandy and mixed land although it has proved to be profitable on the stiff soils. Grading of stiff soils should be approached with caution. Construction problems, such as difficulty of earth moving and planning, are encountered that are not as pronounced with the other soils.

Some of the advantages of land grading are:

1. Provides improved drainage by eliminating low areas which hold water after rains. This increases farming efficiency by permitting farming operations to begin earlier after each rain. Also, crop yields will be increased in these better drained area.
2. Reduces the amount of ditches needed to provide adequate drainage, therefore resulting in more usable acres for crop production.
3. Permits maintenance of drainage ditches by farmer owned mechanized equipment. Eliminates labor and equipment needed to maintain quarter drains and split ditches.
4. Permits more effective control of Johnsongrass or weeds in fields and ditches.
5. Permits more effective use of multi-row equipment.
6. When considered in overall planning, field is prepared for effective and efficient furrow irrigation.
7. Reduces quantity needs for chemicals when spraying by plane.
8. Improves workability of soils in low areas under conditions where plots have coarse textured soil in high knolls that must be moved into the low areas.
9. Increases the acreage in production within a given area.

In summary, the end result of land grading is increased net returns. This is due mainly to increased land in production, better crop yields, more efficient cultivation, cheaper cost for drainage ditch maintenance, cheaper cost for Johnsongrass control, and less chemical when spraying by air. Each of these factors may not be present on each field graded.

Some disadvantages of land grading are:

1. Equipment operators will need to be trained to operate equipment properly to maintain the effectiveness of the land grading.
2. Settling of fill areas may cause some inconvenience in cultivation during the first year.
3. Reduced yields may be experienced in some spots the first year or two. This is normally limited to fill areas in a dry year where the fill and existing soils have not become thoroughly integrated. This condition can, but does not always, restrict upward movement of water,

thereby creating a droughty condition.

4. Cost of establishing land grading.

Land grading is accomplished by use of some type of earth moving equipment (scraper) and a land plane. The scraper is used to do the rough grading work where soil must be picked up and moved from one place to another. Many types and sizes of scrapers are available. Small scrapers are available for use with the heavier farm tractors. Sometimes the small scrapers are pulled in tandem. The land plane is used to remove the minor irregularities after the rough grading.

It is difficult to put a cost figure on land grading. The cubic yards per acre that must be moved can vary widely. The yards per acre moved have gone as high as 1700 cubic yards. (This high yardage was in an extremely undulating area that could not be used for row crops without land grading.) I would think the average for the sugarcane area would be 200 - 300 cubic yards per acre. Another thing that will influence the cost is if the farmer does the work with his men and equipment or hires a contractor. An average cost figure to use for estimating a "turn-key" job by a contractor would be 27¢ per cubic yard (current price). Using 300 cubic yards per acre the cost would be \$81 per acre. Earth moving alone costs about 20¢ - 22¢ per cubic yard. The cost of the land plane is about \$15/acre.

It is also difficult to determine just what to use as a guide for expected increases in yield. There are many variables involved. How poorly did the plot drain before grading? Normally you will expect less increase in the sandy soils than you would in the mixed or stiff soils. Yields must be adjusted to average climatic conditions to show a true picture. Yield increases of from 3 to 12 tons per year per acre have been obtained. By applying the current price per ton of cane an increase in returns can be easily determined. You can see that in some cases land grading could more than pay for itself in a year or two.

Reduced ditch maintenance costs, grass control costs, equipment maintenance costs, etc. should be considered when determining net returns.

I would like to mention that the two main suspected problems in connection with land grading have not developed. Excessive bogging in the fields due to wider lateral ditch spacing has not developed. There has been no special problem crossing the drainage field ditches. By the time the cane cart reaches the ditch the tractor is on firm ground on the headland and far enough out of the rows so there is little tendency to have to pull the cart across the end of the rows.

One of the biggest factors in favor of land grading is that farmers who have done land grading in previous years keep coming back and doing more each year.

I would like to stress one very important practice that should be considered an integral part of land grading. This is the use of water control structures. These structures are placed at the outlet end of drainage field ditches to control erosion where water from the drainage field ditch drops into the deeper drainage main or lateral ditch. Without these structures erosion problems can develop. These ditches carry a lot more water than the quarter drains. A deep wash can develop that will be difficult to cross with farming equipment.

In closing I would like to give you two things that the farmer should give serious consideration to when going into land grading in the sugarcane area (or any other area).

1. Develop a complete plan for drainage and land grading. Plan which areas are to be graded and which are not. Consider needs for roads, farming patterns, etc. Develop an orderly sequence of installation of drainage ditches and land grading. This is especially true in the sugarcane area where once an area is planted to cane, generally it can't be disturbed for three years.
2. Schedule land grading insofar as possible in areas that are not to go back into cane as soon as grading is complete. The biggest hazard involved in the mechanics of land grading is the weather. Unexpected delays in completing construction are always a possibility. Ample time to cover these conditions should be built into the construction schedule.

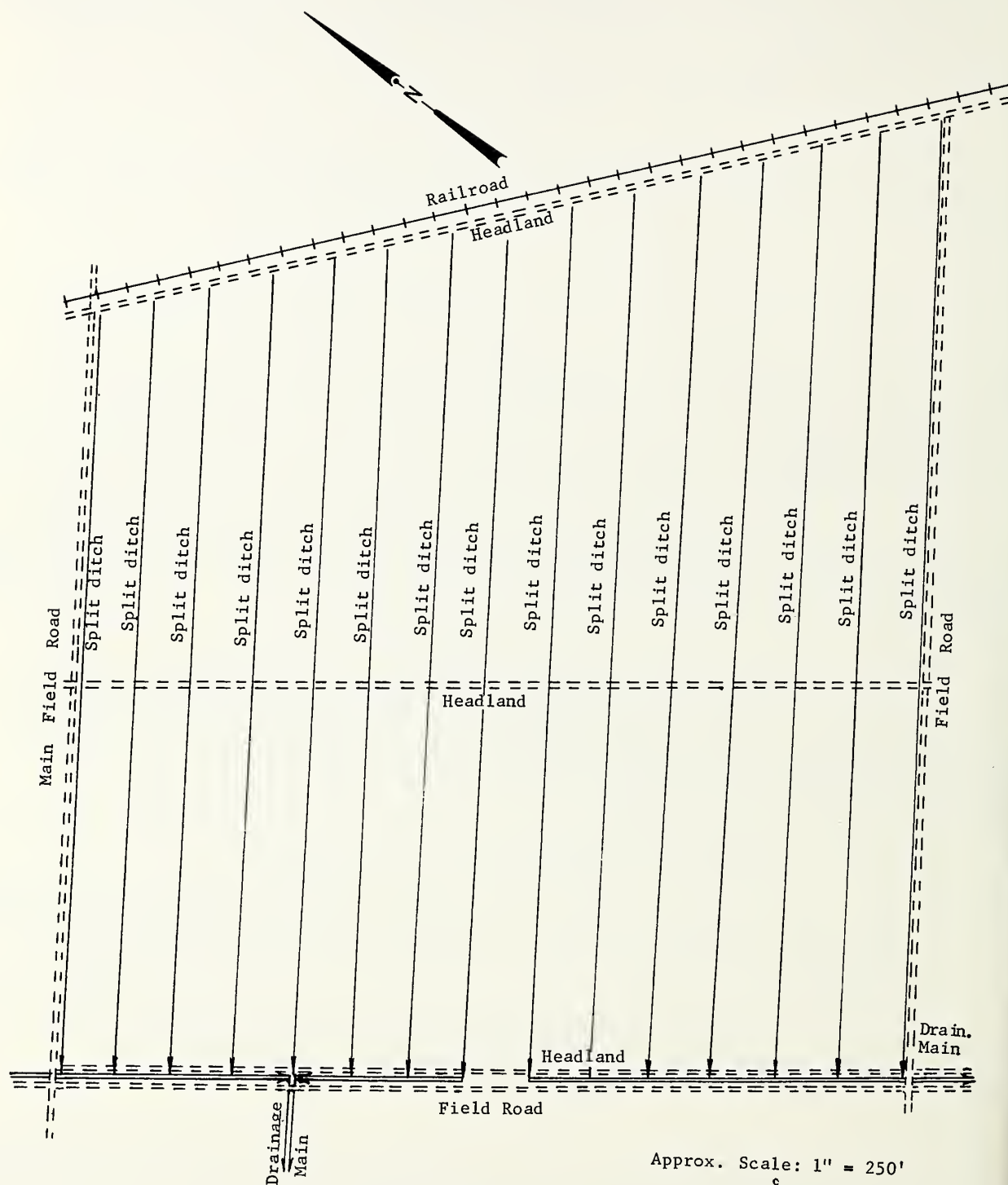


Figure 1
Sugarcane Drainage System
Before Drainage Land Grading

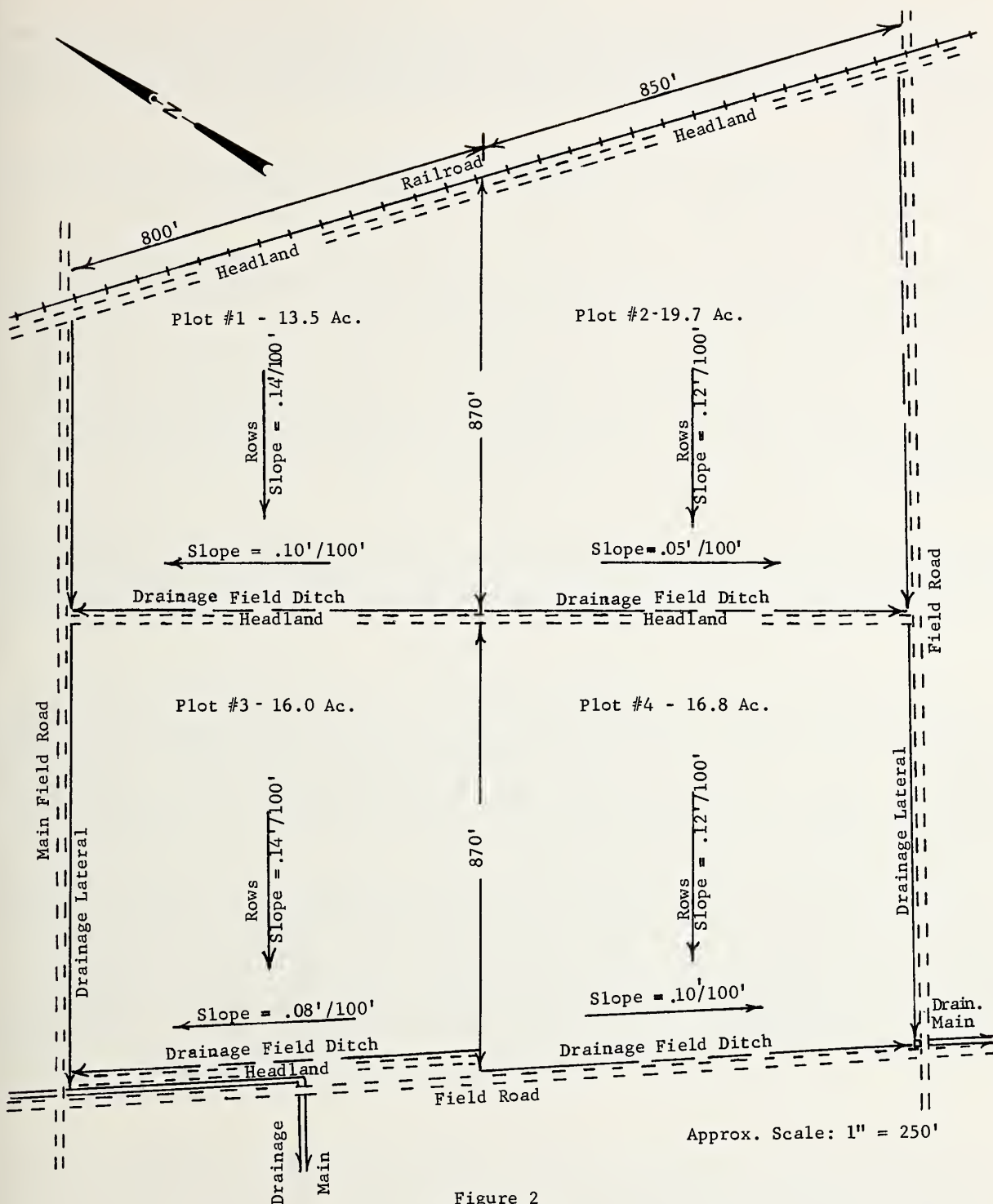


Figure 2

Sugarcane Drainage System After Drainage Land Grading

Joe E. Clayton and Darrell L. Roberts 2/

GENERAL

The problem of cleaning sugarcane has been with us a long time and will probably be with us for a long time to come. Mr. F. A. Vought, South Coast Corporation, presented information to the American Society of Sugar Cane Technologists on cane harvesters and cleaning machines (1) 3/ on June 12, 1941 and he presented material on cane cleaning at the factory (2) on June 30, 1942. Mr. M. V. Yarbrough, Young's Industries, Inc., presented information on milling cane trash and mechanical cleaning (3) on October 3, 1945.

At that time, the common varieties contained about 35% immature top, and almost 10% leaf trash before a freeze. Mr. Yarbrough described a method of removing leaf trash from sorghum used successfully about 30 years previously.

As the harvesting of sugarcane changed from a hand cutting process to a mechanized harvesting and handling process, the need for cleaning was quickly apparent. When sufficient labor was available the cane stalks were stripped by hand as they were loaded. With mechanical harvesting the fields were burned or methods were devised for removing some of the trash.

Some of the earliest sugarcane information published was concerned with patents or experiments on cane cleaning at about the beginning of this century. Some of the first work along this line was done in Australia. In more recent experiments, methods of cleaning were tried by USDA at Houma, Louisiana (4), where the cane was cleaned in the harvesting process. Research on methods of cleaning was also done at Louisiana State University under a contract with the Agricultural Research Service, USDA (5) during the period 1964 to 1968. The mechanisms resulting from this research were later tested by the USDA in Florida (6,7,8).

As the sugarcane stands in the field at the time of harvest in Florida there is usually about 30% trash content by weight. This varies somewhat throughout the season depending on the maturity of the cane, the amount of suckers and the sugarcane variety. In practically all areas where cane has been harvested mechanically, burning has been the primary method of removing the trash before milling. As air pollution regulations become more stringent and the public becomes more concerned, other methods of removing the trash may have to be developed.

METHODS OF CLEANING

One of the first methods of cleaning was by the use of flame either as the field was burned before harvest or by the burning of the cane in the heaprows after harvest. The flame removes only the dry trash which is large in volume but is a smaller part of the trash content by weight. During rainy weather in some areas it is almost impossible to burn and the trash cannot be removed. Spraying water over the mill conveyor was an early cleaning method as the water removed soil from the cane and consolidated and transported the trash from the area. Other systems used pneumatic separation, either by suction or by an air blast, at the mill conveyor.

The use of stripping fingers to remove the leaves from the sugarcane stalks as they were conveyed through the machine was tried. It was found that this was a simple method of removing the trash and it worked reasonably well when the cane was straight. However, it did not remove green trash and complicated the harvesting system. Several types of rolls turning in opposing directions to pull the leaves and tops from cane have been used. This is probably the most aggressive type of cleaner since it will detach green leaves from the cane stalk. It will also do a certain amount of snapping of immature tops from cane pieces. The use of cleaning rolls requires an extremely thin and uniform flow of cane. Also the cane should be chopped into short lengths or the cane should be very straight whole-stalk pieces uniformly fed over the cleaner.

1/ For presentation at the American Society of Sugar Cane Technologists, Baton Rouge, Louisiana, February 4, 1971.

2/ Agricultural Engineers, Sugarcane Harvesting Investigations, ARS, USDA, Belle Glade, Florida and Agricultural Engineering Department, LSU, Baton Rouge, Louisiana.

3/ Numbers in parentheses refer to references at end of paper.

USDA HOUMA RESEARCH

Studies by USDA engineers at Houma, Louisiana, on methods of removing leaves from the stalks included corn husking or stripping rolls, chains mounted on a revolving cylinder, spring tooth fingers, and rubber stripping fingers.

The tests showed that corn husking rolls were not very effective when the stalks were fed lengthwise, or crosswise to the rolls, because the stiff top leaves tended to bridge over the rolls. Satisfactory cleaning could be obtained only when the stalks were hand fed directly to the rolls. A fan to suck the trash into the rolls increased the effectiveness considerably so long as the mat of cane did not become too thick. The difficulty in securing adequate effectiveness and capacity caused this method to be discarded.

Using spring tooth fingers designed for peanut harvesting equipment, resulted in excessive spring breakage. The cane was damaged by the teeth and the trash wrapped around the cylinder during the cleaning operation. Chains also proved ineffective due to the small amount of trash they removed. High-speed movies clearly showed the chains fold or bounce away as they hit the cane stalk.

Stripping fingers made of rubber proved to be the most successful and practical method tested and later became a part of the cutter-cleaner-loader harvester developed under the project. Considerable testing took place using different rubber materials and various shapes before the resulting rubber stripping fingers were designed. The flexible rubber fingers were sufficiently aggressive for removing the cane leaves without inflicting serious damage to the cane although replacement of fingers lost due to breakage or other failures was high. Harvesting rate and leaf stripping efficiency were influenced more by varieties of cane than by the stripping combinations tested.

During the preliminary tests conducted with corn husking rolls for removing the leaves, it was discovered that similar rolls could be used for selective topping. The immature top section of the cane stalk, being soft compared to the mature portion, was easily crushed by small rolls that pulled the cane through until a mature joint was reached. The hard and brittle mature joint broke rather than pass through the rolls.

It appeared that selective topping by means of rolls might be practical for a field machine provided an average topper was used beforehand to relieve some of the load produced by the leafy top. A method of feeding the canes into the rolls at a high rate was needed.

LSU RESEARCH

Methods of cleaning were developed from studies at the Louisiana State University Agricultural Engineering Department from 1964 to 1968. ^{4/} The most promising cleaning method was with polygon cleaning rolls. Shapes tested were 1 1/2-, 2 3/8- and 3 1/2-inch square rolls, triangular rolls and 5-inch O.D. hexagonal rolls. These studies included a consideration of the "effective pocket" between pairs of rolls as affected by roll size and speed.

The polygon rolls could be operated within a wide range of speeds without reducing cleaning efficiency. However, due to clogging and mature cane loss, the 2 3/8- and 3 1/2-inch square rolls, and the 5-inch hexagonal rolls should operate at a minimum speed of 450 rpm and a maximum speed of 700 rpm. The percent trash removed by the 1 1/2-inch square rolls and the 1 3/4-inch triangular rolls was significantly lower than the other types of cleaning rolls tested. These rolls were small enough to be subjected to wrapping of the leaf trash and were not considered to be effective.

A cleaning unit consisting of square and hexagonal rolls was used in Florida in conjunction with a mechanical harvester and was effective in removing approximately two-thirds of the total trash in cane. It was apparent that a higher percentage of trash could have been removed if the cane had moved over the rolls in a relatively thin mat. The cleaning unit used in Florida was effective in capacities averaging 14 tons per hour. However, it must be considered that these units were experimental laboratory-sized rolls. A larger unit designed for field conditions with a wider surface at the beginning of the cleaning operation and a method of breaking up the bundles or slugs that come out of the conveyor should increase the performance of the cleaning rolls.

USDA FLORIDA RESEARCH

The USDA experiments with the polygon shaped rolls developed at LSU were concerned with field tests of their efficiency and capacity. The rolls were placed in three different arrangements in order to thin and uniformly feed the cane over each of three cleaners. They were first tested with the three sets of cleaners in direct line but it was found that the cane was moving too fast to allow much cleaning by the second and third set of rolls. The cleaners were then placed in a zig-zag path so they could be used to turn the cane and perhaps get better agitation and exposure to each cleaner. In the final tests a conveyor was added to the cleaner so that the cane from the third cleaner was conveyed to the wagon. All of these tests were made using chopped cane in Florida.

^{4/} This was supported by a research contract from Agricultural Research Service, USDA.

The rolls have several advantages so that they could be used in present systems of conveying from the harvester to the transport. The rolls will separate loose trash and will detach trash adhering to the stalk. The rolls will do a certain amount of snapping of immature tops from the mature cane pieces. The disadvantages of the rolls are their requirement for a thin and uniform flow, their limited capacity when used in transport or handling situations, their requirement for more power than pneumatic systems, their low capacity in heavy trash and the loss of some cane.

RESULTS IN 1970, LOUISIANA WHOLESTALK CANE

SPIRAL ROLLS

The spiral cleaner was a large cane table for cleaning grab loads of wholestalk cane. This unit was mounted as a sloping platform so that cane could be conveyed down the platform, across the cleaning rolls, with the stalks parallel to the rolls. One set of cleaning rolls was a steel spiral unit, nine feet in length. The second unit was similar in design but was made of aluminum material and the spiral specifications were changed slightly. Each cleaning unit contained six spiral rolls. This cleaner was powered by a diesel engine and used hydraulic drives in order to quickly reverse the rolls.

The first tests were made on October 7, 1970, with variety L.60-25 containing about 40 to 50 percent trash in the form of tops, leaves, Johnsongrass and some soil. These first experiments with the large cleaner indicated the problems in handling wholestalk cane with any method other than a grab or sticker chain. The material contained so much trash, and the cane stalks were so short and brittle, that it was almost like handling hay. Three chains for distributing the stalks onto the rolls did not work due to the type of material. At the time of the first tests, augers for conveying the cane were not completed. In these original tests, 23 percent to 50 percent of the material applied to the rolls passed through the cleaner as trash (Table 1). This included some cane which was estimated at about 5 percent. Again, the rolls did an excellent job of cleaning the trash, but some cane was lost and conveying was the major problem.

The clean stalks were pushed against the end of the rolls by the spirals and would not move from the cleaner. The stalks could not be routed from the bottom of the cleaner to remain in a form which could be picked up by the grab loader.

During the week of October 12, 1970, 24-inch diameter augers were placed above the rolls in order to pass the cane down the slope uniformly. Unfortunately, the augers ordered were of the wrong configuration and accentuated the problem of cane moving to the side or end, instead of opposing this movement. These augers were removed since they interfered with efforts to straighten the cane by hand.

One of the purposes of testing the rolls in Louisiana was to determine their efficiency in muddy conditions. Some mud built up in the corners against the spirals but the area of spiral contact was kept clean. The mud was generally pulled through with the trash but the dry clods passed over the rolls with the cane.

The experiments in cane cleaning at Thibodaux, Louisiana, have shown that these types of rolls will remove limber material from sugarcane. The primary problem is in getting the cane properly exposed and moved over the rolls without allowing excess time for mature cane to be pulled through. The cane must be properly exposed to the rolls in a thin mat and moved swiftly and uniformly across the rolls. It is very difficult to feed cane uniformly after it has been grab loaded, since the crushed stalks may be grabbed by the cleaning rolls. It seems that proper feeding will be hard to accomplish with wholestalk cane and even more difficult with crooked wholestalk cane. We can expect some cane loss when we are trying to do a difficult job like removing the immature top from a mature piece of cane. In certain instances there will be too much pressure on the mature cane stalk and some of it will be lost. In other instances there will be too much pressure on the mature cane stalk and some of it will be lost. In other instances there will not be enough pressure and the immature top will pass over the rolls without being removed.

The following tables show some of the data acquired from the tests October 5 through October 23, 1970.

TABLE 1. Trash removal by spiral roll wholestalk cleaner, Thibodaux, La. Variety L.60-25, unburned.

October 7, 1970			
Test No.	Sample Weight		Trash Removed <u>1/</u> (percent)
	Lbs. Before Cleaning	Lbs. After Cleaning <u>2/</u>	
1	254	180	29.1
2	185	109.5	40.8
3	205	148	27.8
4	184	136	26.0
5	203	141	30.5

Average = 30.8

October 8, 1970

1	588	370.8	37.0
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Hand Cleaned Sample

1	78.0	55.7	28.5
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NOTE: Hand sample was cleaner than average.

1/ Contained about 5 percentage points mature cane.2/ Stalks still contained some trash after cleaning.TABLE 2. Trash removed by spiral roll wholestalk cleaner, Thibodaux, La. Burned cane. 1/

October 15, 1970			
Test No.	Sample Weight		Trash Removed <u>2/</u> (percent)
	Lbs. Before Cleaning	Lbs. After Cleaning <u>3/</u>	
1	150	110	26.6
2	125	65.6	47.5

NOTE: Both samples had cane in trash.

1/ Poorly burned cane from mill and spilled cane from unloader. Steel rolls 500 rpm, aluminum rolls 550 rpm, 550 psi running.2/ Contained about 5 to 10 percentage points mature cane.3/ Stalks still contained some trash.

EXPERIMENTS WITH PAIRS OF ROLLS TO HELP IDENTIFY VARIABLES

Since some cane was lost in tests with the wholestalk cane at Thibodaux, Louisiana, we decided to try experiments with pairs of rolls in order to more easily determine the best specifications for the spirals. A pair of rolls with the spiral progressing toward the center were built with the double spiral wrapped on 10-inch pitch. These were constructed into a test frame with drives by Cary Iron Works 5/ and tested by LSU engineers. By reducing the spiral pitch by two inches, the aggressiveness is reduced and there is less open space for cane loss. The spirals should move the cane toward the center, away from the bearings and shields.

5/ Mention of this firm does not constitute endorsement of its products by the U.S. Department of Agriculture over similar firms or products not mentioned.

An attempt was made to convey cane over the rolls with a single sticker chain at the center point where the spirals meet. This was unsuccessful since the cane was not held rigidly. Two sticker chains were installed to feed the cane and the cleaning was satisfactory with the cane held in these chains. There was still some cane loss with this system although a prolonged test could not be made with the unit.

Cane with tops from a field after a freeze was spread across the rolls in batches of 6 to 20 stalks per run with two sticker chains positioning and conveying the stalks. Other trials involved use of pressure bars over the sticker chains and various rate of feed. Cane loss in the order of 10% was experienced in these tests. Most of the cane loss appeared to be adjacent to the center ring where the spirals met. This ring was removed with no significant reduction in cane loss being noted.

Recesses were cut in the center spiralling rolls for the two sticker chains so that the cane was held closer to the spirals. Wide pressure plates were also placed over the cane to hold it to about two inches above the rolls. In these tests trash removal appeared to be about 40% with a few of the tops being removed. By controlling the cane rigidly with the sticker chains, the loss of cane was practically eliminated.

Pairs of hexagonal rolls made from the cold-formed material manufactured by Timken Bearing Company were also tried. The factory tubing had 3/8-inch radius corners. In tests with the standard material, 40 to 50 percent of the trash was removed from the stalks and some cane was lost. It could not be determined if the loss was occurring at the groove cut for the sticker chain.

The corners of the hexagonal rolls were machined to reduce the diameter across the corners from 5.70 inches to 5.59 inches. The cleaning was satisfactory with the machined rolls and there was no loss of cane through these rolls under experimental conditions. A cleaning unit with six hexagonal rolls was built for further testing.

FUTURE DEVELOPMENT

Spiral or hexagonal cleaning rolls will remove the types of trash found on sugarcane in Louisiana and Florida. With some further production engineering work, they can be made durable and will operate with low maintenance. Additional thought should be concentrated on how these cleaners can be used in the Louisiana harvesting system and who will bear the cleaning expense.

The ideal method would be to operate the cleaner through the field so that the trash could be dropped on the ground. The cleaning operation could possibly be combined with the grab-loading or a continuous loading system. Cleaning could also be done at a cane transfer point or at the mill conveyors.

MILL SAMPLE CLEANER

A small unit using hexagonal rolls was assembled to clean the 50 to 80 pound mill sample for trash analysis. This cleaner was powered by an electric motor using hydraulic drives and the cane sample was chopped into short lengths, dropped over the cleaning rolls and discharged into a container. The corners of these rolls were built up by welding to provide a sharp corner with 5 3/4-inch diameter across the corners.

The sample cleaner was used with variety L.60-25 containing 40 to 50 percent trash in the form of tops, leaves, Johnsongrass and some soil. The hexagonal rolls cleaned the materials almost perfectly but some cane was lost. When the rolls were new, losses were as much as four 18-inch pieces of cane in 50 pounds, or about 4 percent loss. As the chopped pieces drop onto the rolls, cleaning is accomplished in 5 to 10 seconds but it took 1 to 1 1/2 minutes to chop the sample. Since the entire sample was kept on the rolls, some mature cane was lost before dumping.

The rolls were tried by chopping the cane and then dropping the entire sample on the cleaner immediately. It worked much better this way although some cane was still lost. Possibly the square corners of the rolls could be rounded somewhat to prevent the grabbing of the smaller diameter Louisiana stalks.

Table 3 shows some of the data acquired from the tests made October 7 and October 8, 1970.

CONCLUSIONS

The use of air separation or cleaning rolls at some point in the conveying process would seem to be the most reasonable method of cleaning leaf trash and tops from cane. Considerable work has been done with cleaning rolls for cane and they are a proven method of working in corn. The rolls are the best cleaning method that has been found but more work is needed on the production and maintenance problems associated with operation of rolls.

Air separation or cleaning rolls can be installed in the harvester conveying mechanisms although they complicate the harvesting system somewhat. These systems can be more easily installed at a transloading point or in the mill conveyors but the removal and transportation of the trash from the sites becomes a problem. The trash from these drycleaning systems is not dense and required considerable conveying or transportation space. Under dry situations the trash is a real fire hazard. No doubt, cleaning the cane will be done at the harvester, at the transloading point, at the mill, or perhaps all of these locations at some future date.

TABLE 3. Trash removed by mill sample cleaner, Thibodaux, La. Variety L.60-25.

October 7, 1970					
Test No.	Sample Weight		Trash Removed (percent)	Remarks	
	Lbs. Before Cleaning	Lbs. After Cleaning <u>1/</u>			
1	50.0	29.5	41.0		
2	60.0	36.0	40.0		
October 8, 1970					
1	87.1	25.0	71.2	Lost some cane	400 rpm
2	52.4	35.0	33.2	Lost some cane (4 lbs.)	450 rpm
3	58.1	39.1	32.7	Lost 2 pieces cane	500 rpm
4	52.5	35.5	32.3	Lost 3-4 pieces cane	500 rpm
5	62.6	32.0	48.8	Lost 3-4 pieces cane	500 rpm
6	51.7	24.3	52.9	Lost 1-2 pieces cane	500 rpm
Average = 45.2					

1/ Cane pieces had 0 to about 1% trash remaining after cleaning.

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TRASH DETERMINATION AND SAMPLING PROCEDURES FOR MILL CANE

B. L. Legendre
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Trash can be defined as worthless things, refuse, or rubbish. The guidelines or regulations for determining trash in sugarcane delivered to the mill are found in the pamphlet 8-SU, Sampling, Testing and Reporting, (1) compiled by the Agricultural Stabilization and Conservation Service, an agency of the U. S. Department of Agriculture, separate from the Agricultural Research Service which carries out the program of the U. S. Sugarcane Field Station at Houma, Louisiana.

The regulations separate trash into five categories: 1) leaves and suckers; 2) loose tops which were cut in the field by the harvester but carried to the mill; 3) intact tops remaining on sugarcane stalks (or stalks topped above the last formed joint) or all growth above the third last formed joint from the bud; 4) roots and all growth below the ground level; and 5) extraneous material contained within the sugarcane load. All five categories would fit the definition of trash as being worthless in the production of sugar with the possible exception of that cane below ground level. Experimental work needs to be done in Louisiana to determine if below ground level cane contains sufficient sucrose to be economically important. Studies should be made of the amount and quality of juice extractable from such cane pieces. A study of the milling quality of stubble pieces of syrup varieties was made in Mississippi during the early 1950's (5), but the study was limited to the analyses of Brix and sucrose.

There is difficulty in determining how much of a cane stalk is top, and therefore, trash. Growers and processors agree that there is a portion of the stalk near the terminal bud which contains little sucrose. This area varies considerably between varieties, seasons, and crops (i.e. stubble vs. plant cane crops). The Agricultural Stabilization and Conservation Service, in order to eliminate what they consider uncertainty and provide a uniform system by which all mills could adhere, arbitrarily set the present standards. The present standards may favor the harvesting of cane low in quality if so little of the top is removed as trash. A group of agricultural scientists was appointed by the Grower-Processor Committee to determine the proper level of topping; their recommendations being rejected. In many instances mill personnel, in their samples from grower's deliveries, continue to adhere to the old policy of topping sugarcane stalks at the last hard joint because compliance with the new regulations requires more time and is too technical in nature.

The recommended methods for obtaining cane to be used in trash analysis of a grower's sample do not guarantee representative sampling. The regulations specify that samples weigh at least 50 pounds; that they shall be taken from loose sugarcane manually or mechanically; and that bulk deliveries are to be sampled after dumping. No further provisions are made to avoid sampling error.

Bias can easily be introduced into samples pulled for trash determination. Dr. Keller of Louisiana State University showed differences between trash percentages of sugarcane taken from small samples and from entire loads (4). In every case the trash percent of small samples was less than that found from the entire load of several tons. Normally, the larger the sample, the more representative the sample; however, the size is limited by the time required to clean or detrash the samples. Handling cane several times before samples are pulled will undoubtedly result in lower trash percentages for the producer no matter whether the cane was mechanically or manually pulled for the sample. Leaves, shucks, mud, etc. are sifted through the load causing a lower analysis for trash. Cane pulled manually, either singly or in groups of two or three stalks from the end of a bundle where cane is handled in slings, will result in detraging leaves from cane before a gross weight can be determined.

Samples for trash should be made with as little movement of cane as possible to prevent sifting of trash and mud through the sugarcane. All sampling should be as uniform as possible. Preferably, all samples should be taken with the mechanical grab. The grab should be so constructed to allow the entire sample to be taken with one action. Grabs which are too small or too weak to completely close result in poor sampling.

The recommended sampling rates also permit non-representative sampling. If a producer's normal deliveries are less than five tons daily, one weekly sample is required. If the daily deliveries are from 5 to 100 tons, then one daily sample is required. If the daily deliveries are more than 100 tons then more than one daily sample may be taken. While the grower and processor must agree to multiple daily sampling, no guidelines have been given for reaching this agreement. In practice the number of daily samples taken is at the discretion of the processor.

It is obvious that the processor is unable to sample every conveyance for trash due to the time required for properly analyzing each sample and the increased rate of grinding at most factories. However, a trash sample could be taken whenever a sample is taken for sucrose. The regulations state that all cane is to be sampled for sucrose at least every 65 tons, but does not require such frequency

for trash determinations. If simultaneous samples were taken, then these two quality indicators, sucrose and trash, would have the same sample selection basis.

The grower is paid for these two items; for trash free or net cane, and for the sucrose in that cane. The gross weight of the cane sampled for trash determination is obtained, then all trash is removed by hand. The sample is re-weighed and the trash percent determined by dividing the trash weight of the sample by the gross weight. The percent trash is applied to the shipper's deliveries for that period covered by the trash determinations and the product is deducted from the shipper's gross cane delivered; the resultant, the net cane delivery. Thus, if a grower ships one hundred tons and has 10% trash, he is paid for 90 tons. The trash also affects the second standard of payment, sucrose content, because trash in the cane sample for sucrose is not removed. Some have said that the grower is being penalized twice for trashy cane. This claim is made by those who think that the only effect of trash is to reduce the amount of real cane delivered. Sugar recovery is adversely affected in two ways because of trash: reduction of amount of net cane ground and its retention of sugar. The presence of trash not only adds nothing to the pounds of sucrose in a ton of cane, but the bagasse formed by the trash absorbs juice containing sucrose, reducing the sucrose recovered (2). Trash also reduces the grinding rate, and organic acids in the tops and leaves reduce boiling house efficiency (3). Field mud, frequent in bulk cane, but rare in trash samples, causes similar losses. Since the presence of trash lowers the amount of net cane and the amount of sucrose obtained, the dual sampling method is ethical and necessary to insure the delivery of fresh, clean cane to the mill.

It might be well to note that the producer has the right to inspect all trash and sucrose sampling at the mill. A grower should realize the seriousness of delivering poor quality cane to the mill and a knowledge of the sampling techniques might be a wise investment to the farmer.

Discrepancies in trash percentages occur for the same cane being delivered to different mills. The trash determinations were different because the methods and frequency of sampling were different. These differences were found when one mill used the mechanical grab and another pulled samples by hand. Since different personnel and equipment are employed in sampling at the various mills, minor discrepancies will occur when the same methods and frequencies of sampling are used. Differences even occur in trash percentages for cane from the same grower at the same mill. Frequent sampling will reduce these errors.

There is a need for extensive revision of the definition of sugarcane trash and the methods of determining it. A cane top should be redefined so all of the stalk not suited of sugar production would be classified as trash. The quality and amount of juice of stubble pieces needs to be determined so that this material can be properly classified as trash or millable cane. Sampling frequency could be increased so that trash determinations are on a par with sucrose sampling. Mechanical removal of trash samples would reduce time and error and increase the uniformity between mills. Any regulations must insure standard sampling at all mills.

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INTRODUCTION

Details of the design and operation of two modified versions of the Julien cane planter are included in this paper to supplement the film titled "Mechanical Cane Planting in Louisiana." This film was sponsored by the American Sugar Cane League and is centered upon planters operated by Mr. Paul Cancienne of Savoie Industries, Belle Rose, Louisiana, and the Paul and Wilmer Poche Farms, Convent, Louisiana. These Planters possess some important design modifications over earlier models and it is felt they represent the current status of efficiently operated mechanical cane planters. The following detail should give some inkling of the future outlook for this machine in Louisiana.

It is generally agreed that agricultural machines do not gain wide acceptance until they are modified to incorporate features that are desired by the user. This appears to be particularly true for the mechanical cane planter. As a consequence of this, pioneering of the mechanical cane planter has continued over the last 5-6 years. Much improvement has been made in the planter in recent years and these improvements can be principally, though not entirely, attributed to design innovations which originated with and were engineered by the user himself.

DESIGN AND OPERATION

Savoie Industries operates five planters of the type shown in Figures 1 and 2 which were built by Mr. Morris Daigle and Mr. Paul Cancienne. Figure 3 shows another planter which was modified and is operated by Paul and Wilmer Poche. In discussing these planters they will be referred to as the Type 1 and Type 2 planters, respectively.

Both of these planters are designed to mechanically separate whole stalk cane from the cane mass within the planting cart and to transport this cane to a position such that it can be dropped without interference into a previously opened furrow. Since mechanical separation of individual stalks from the cart is the most critical task in the planter's operation it will be discussed first.

Mechanical separation is accomplished by the chain driven fingers which rotate about the planting arm shown in Figure 1. The planter operator controls the position of the arm and fingers by hydraulically positioning the boom such that the most efficient and uniform extraction of the cane is obtained. This requires constant repositioning of the mechanism both vertically and laterally within the cart. In order to pull the cane from the cart it is necessary that carts be loaded with the butt ends all to the rear end. The boom is positioned vertically such that the fingers can grab stalks close to their butt ends and carry them rearward to a position clear of the cart and are then dropped.

In Figure 1 it can be noted that there are three fingers on each of the two chains which rotate at the same speed and parallel to each other. The finger speed setting is dependent upon the amount of cane overlap desired in the furrow and upon the speed of forward travel. Normal planting speed is about 4 m.p.h., however, some growers plant at speeds up to 5 1/2 m.p.h. More uniform planting seems to be evident at the slower of these two speeds. When planting speed is selected then the finger chain speed can be hydraulically set to give the desired overlap in the furrow. This is not altered during the planting operation and therefore the operator can concentrate on controlling the lateral and vertical motion of the finger assembly.

The finger on the Type 1 planter is a modified form of the Julien finger, which is the finger used on the Type 2 planter. In Figure 1 it is to be noted that the fingers are designed such that the jaws spring open by compressing the ears just like a clothespin is opened, whereas, the jaws of the Julien finger are opened by spreading the ears apart rather than compressing them. As the fingers in Figure 1 rotate from the top around the front end of the arm their ears pass through a narrowing passageway, thereby opening the jaws. The ears exit the passageway when the finger is in the cane contact position, thereby closing the jaws upon the cane. Similarly, at the rear end of the finger arm assembly a passageway for the finger ears causes the jaws to open and the cane drop is accomplished. The Julien fingers operate in a similar way using the above method to open and close them.

¹Presented at American Society of Sugar Cane Technologists Meeting, February 4, 1971, held in Baton Rouge, Louisiana.

While maintenance requirements have been found to be quite low by Savoie Farms, these are believed to be a direct function of the human element involved in the operation, i.e. the operator's watchfulness and concern for efficient utilization. Mechanical difficulties have been mostly associated with the bending of fingers and chain wear resulting in flexibility at the fingers. On the basis of this, guards were provided to protect the fingers and chains as the assembly contacted the cane cart when moved from one side to the other. These guards can be seen in Figure 1 at the front and rear of the assembly.

The Type 1 planter has its own power unit and can act as a prime mover in the operations of connection and disconnection from the cart. At all other times it is physically linked to the cane cart and is being pulled by the tractor shown in the front. The planter operator is seated to the rear of the planter with his eye level at about the level of a loaded cart. The operator of the Type 2 planter is seated on a tractor mounted planter with a seating position several feet above and to the rear of the planting mechanism. Figure 3 shows that the operator has a good overall view that enables him to rapidly see most mechanical difficulties that might occur. This view would also assist in obtaining the best placement of the assembly in observing the manner that cane is being pulled from the cart, as well as its path from the cart to the catching aprons of the planter. Both planters appear to give the operator a good view of the system in operation. The Type 2 planter requires three men for its operation, the planter operator and two tractor operators. In this planter the frame is not physically linked to the cart, but is merely butted and driven against the cart. Thus, the rear tractor is the prime mover. It must have sufficient power and weight to support the planter and to push the front tractor and cane cart at a suitable planting speed. The front tractor remains in neutral and the operator just steers. A heavy concrete weight is attached at the rear end of the driving tractor to provide satisfactory balance and traction. The planter frame is vertically positioned to make suitable contact with the rear end of the cane cart and after the tractor mounted planter begins pushing the cart relatively little difference in vertical position results between the two.

The principal control function of the operator is to regulate movement of the finger-arm assembly across the top of the seed mass such that cane will be removed in even layers. It is also his function to hydraulically elevate the boom to clear the top of the cane cart when connecting the planter to a full cart. Lifting of the boom is also necessary when turning at the headlands.

Since the Type 1 planter is to be physically linked to the cart, it was desirable to provide a means for easy vertical positioning of the planter front end. The hydraulic lift directly above the planter front wheel (Figure 2) is used for this purpose. In the connection operation the front tractor and cart remain stationary while the planter is driven against the cart. The male portion of the hitch is attached to the cart and its mating part is on the planter front end adjacent to a connecting arm linkage used in the turn operation. After connection is complete, the weight of the planter front end is shifted from the front wheel to the rear end of the cane cart. Then the planter can move vertically with the cart as it passes over terrain irregularities.

The planter operator also controls the partial disengagement and separation of the planter from the cart in the turn operation. The hitch is disengaged and the connecting arm remains attached to the cart. A horizontally positioned hydraulic cylinder is extended; thereby forcing the connecting arm to separate the planter from the cart by about 2 1/2 feet. The front tractor pulls the cart and planter throughout the turn. When the turn is complete the ram on the cylinder is retracted to close the gap between cart and planter and to make the positive hitch. Turning is accomplished with very little lost time.

The degree of success achieved in the planter's operation is to a large degree dependent upon the type of cart used and the manner in which it is loaded. Since 3-row heaps are used, all of the butt ends are oriented in the same direction and can be loaded to the rear end of the cart. In filling the carts the loader should be operated such that relatively small bundles of 500 pounds or less are grabbed. The loader operator attempts to push the cane rather than roll it; thereby preventing excess wrapping of the leaves about the stalks. This type of loading enables the planter to operate much more acceptably and reduces the percentage of finger misses, i.e. no cane grabbed by a finger as it passes over the mass.

The capacity of the cane carts used varies somewhat, however, most are loaded with about 1 1/2 to 2 tons of seed cane. Little modification is required to adapt cane carts to the planter. First, a hitch would have to be provided for the Type 1 planter. Several hitch designs have been tried and two of these which appear to work quite well are used by Savoie Farms and by the Alma Plantation, Lakeland, Louisiana. A second modification is to line the insides of the carts with a plywood or sheet iron cover to provide a smooth surface for the fingers or guards to operate against. About nine feet of length should be provided at the rear end of the cart. Thus, it might be necessary to add a partition in some carts to fix the cane in the most desirable position with respect to the planting mechanism.

Savoie Farms has found that a single planter requires three carts for efficient planting and when 2 or more planters are operated the cart requirement is 5 for 2 planters.

Since the planter does not do a perfect job, manual labor is necessary to fill skips in the furrow and to thin bunched cane drops, particularly at the ends of rows. The number of people used behind each planter is typically from 2 to 4. This number depends upon the variety and condition of the cane as well as upon the operating efficiency of the planter. The more brittle varieties are somewhat harder to plant. More difficulty is encountered when leaves are wrapped around the cane and also when using crooked cane. Based upon this, the planter was more efficient in 1969 than in 1970. It has been observed that the manual labor requirements are less in the afternoons than in the mornings. This can be largely attributed to improved planting as the cane dries during the day.

MECHANICAL PLANTING REQUIREMENTS AND BENEFITS

This was the 4th year of complete planting with Type 1 mechanical planters on Savoie Farms. The acreage planted varied between 1300 and 1500 acres per year and the number of planters used was 5 in 1970 and 4 in 1969. The planting rate varied from 12 to 15 acres per day per planter. Mr. Jules Dornier, manager of the Helvetia Sugar Cooperative, indicated that a good planting rate for the mechanical planters in the Cooperative was 10 acres per day per planter. Approximately 20 mechanical planters (about 1/2 Type 1 and 1/2 Type 2) are used in the Cooperative to plant 75% of their cane, or something over 5,000 acres mechanically planted. Consideration of these figures would imply that each planter is being used to plant approximately 275 acres per year. When difficulties are encountered, e.g. poor cane or mechanical difficulties with fingers, the rate of planting has been on the order of 6 to 8 acres per day per planter.

Based upon an estimated average planting rate of 10 acres per day per planter manpower requirements of 5 men per planter this would yield a manpower acre rate of 2 acres per day per man. Therefore, machine planting requires only 1/2 the planting personnel as compared to a typical manual planting rate of 1 acre per day per man. Savoie Farms records reveal this requirement to be even lower.

The amount of seed cane used varies from grower to grower. However, records indicate that mechanical planting can be accomplished with an increase of about 10% over a normal 4 tons per acre for manual planting. It has been indicated that some growers plant as much as 1/3 more seed per acre with the mechanical planter as compared to manual planting. However, it is felt that such heavier planting rates result in higher yields.

The last cost that was heard quoted for the planter was \$6,600.00 to the manufacturer. There would also be some additional costs for adapting presently used cane carts to the planter and also for the additional tractor if a Type 2 planter were selected.

FUTURE OUTLOOK

Mr. Arthur Lemann, Jr. of Donaldsonville, Louisiana indicated in September, 1970 that 55 planters had been sold and has recently indicated that 17 mechanical planters were put in the field during 1970. If the previously given planting rate per machine were assumed to be the same for each of the planters in operation, this would imply that about 20% of the 1970 planted acreage was mechanically planted. While manual methods are being used to plant the majority of the crop, there is good evidence that the complete mechanical planter will be getting a larger share of the crop. Improvements in the machine and the possibility of future labor shortages are 2 good reasons for the growers' interest. However, it should be re-emphasized that the success or failure of this machine is dependent upon the "human element" in its operation.

ACKNOWLEDGEMENTS

Special gratitude is extended to the following persons who assisted by providing information and cooperating in the filming of these operations:

Paul Cancienne, Savoie Farms, Belle Rose, Louisiana
Paul and Wilmer Poche, Convent, Louisiana
Jules Dornier, Helvetia Sugar Cooperative, Convent, Louisiana
Arthur Lemann, Jr., Donaldsonville, Louisiana

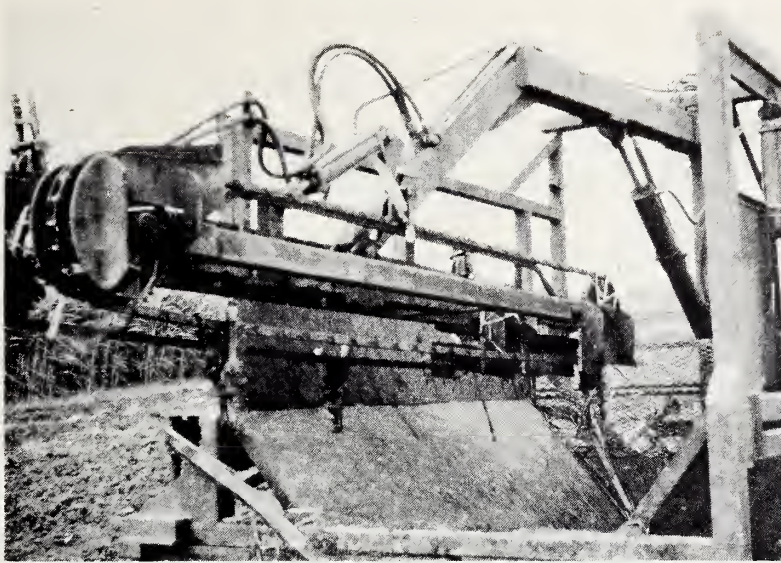


Figure 1. Detail of the Finger Grabbing Mechanism on the Savoie Farms Planter (Type 1)

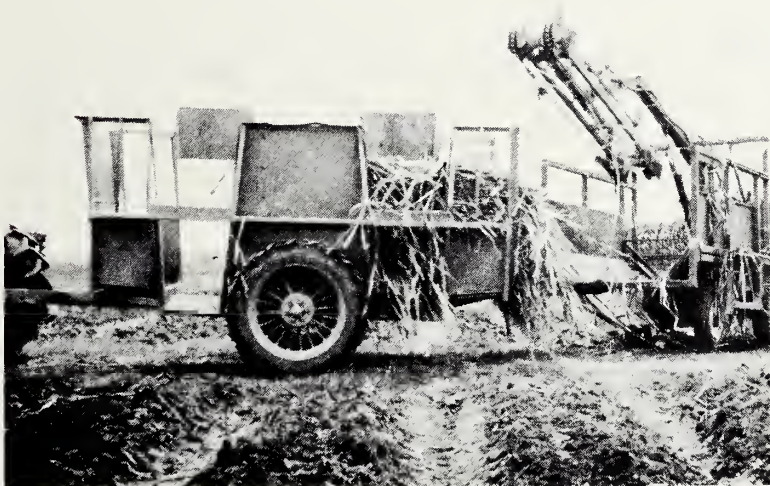


Figure 2. Turning Operation with the Savoie Farms Planter (Type 1)



Figure 3. Planting with the Poché Farms Planter
(Type 2)

AUTOMATIC CRUSHER FEEDER

Juan M. Campaneria
Factory Manager and Chief Engineer
The South Coast Corporation
Oaklawn Division

We do not have to emphasize how important it is to have uniform and constant feeding in a mill to have a good extraction.

This is very difficult to have when you are depending on a human operator, who in many cases does not know how important is his job. Frequently he feeds very lightly to avoid choking the crusher and in other cases feeds too heavy and then chokes the crusher.

Only by having an automatic feeding system can you control the thickness of the bagasse blanket.

There are many automatic systems in the cane sugar industry. All of them can give good results, but their prices range from not too high to very high, depending upon how complicated they are.

The system we are going to describe, as shown on attached sketch, is one of the most simple and less expensive as far as we know and, what is more important, it works, and works without giving any trouble.

In the summer of 1969 we installed in Oaklawn Sugar Factory a centrifugal limit switch (7) to control the overload in the one set of knives we have. This limit switch, (Euclid, double pole, normally open) energizes two Atkomatic solenoid valves, (4) (normally open, energized to close) that shut off the live steam to both cane carrier engines when the set of knives loses speed, and de-energizes both valves when the knives regain the normal speed.

This installation was only to prevent the chokes on the knives and since it was installed, we never have had chokes in the knives.

From this installation to the automatic feeding system was only one step.

Last summer, using surplus equipment, like a 1" second hand diaphragm valve and a type 779K Fisher Pilot kept in stock in the factory, we completed the second step in the automatic system.

Installing a 1-1/4" shaft across the crusher chute and two pipes fixed to the shaft by set screws, we made the "sensors" (1) to "feel" the height of the cane mat in the chute. These sensors can be adjusted to change the quantity of the cane fed.

A cam fixed at the end of the shaft transmits the signal to the Fisher pilot, (2) which controls the speed of the cane carrier No. 2 by closing or opening the diaphragm valve, (3) installed in the inlet line of the steam engine.

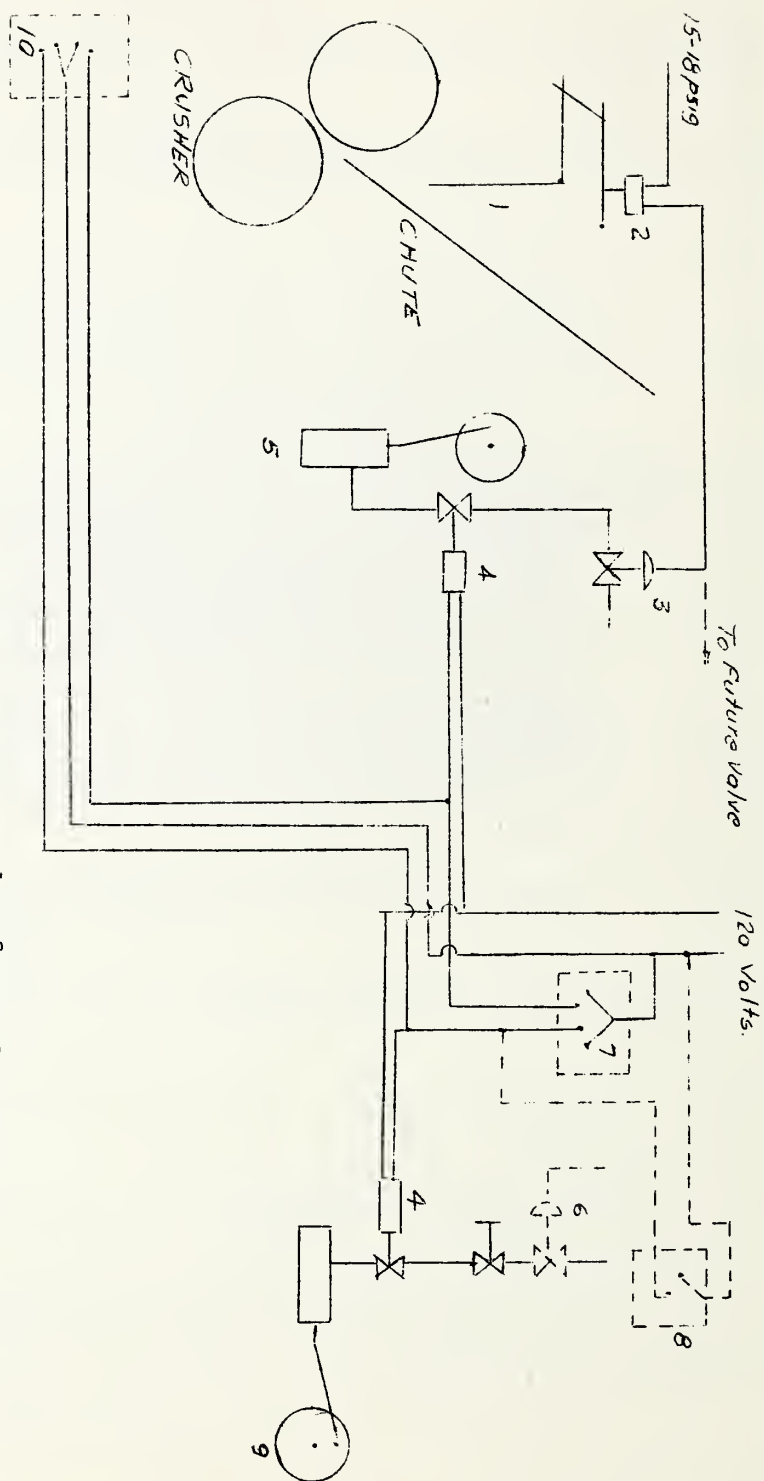
For an emergency stop, we installed a double pole, on and off, hand switch in the mill control panel, connected in parallel with the limit switch in the cane knives, which shuts down both solenoid valves, stopping both carriers.

This summer we are planning to install another set of knives in the cane carrier No. 1. Then we can complete the third step of the system.

This third step is shown in the sketch by dotted lines. In the live steam line of the cane carrier No. 1 engine we are going to install a diaphragm valve (6) controlled by the same Fisher Pilot, (2) which will control the speed of the cane carrier No. 1.

In the new set of knives we are going to install a centrifugal limit switch, which will energize only the solenoid valve installed in the live steam line of the cane carrier No. 1 engine when the speed of this set of knives falls below normal, and opening when it regains its normal speed.

This year we were able to reduce our crew in the mill room by two men. Next year it may be possible to remove two men from the cane carrier. This is another important point to be considered.



- 1 - Sensors
 - 2 - Fisher type 779K Pilot
 - 3 - Diaphragm Valve
 - 4 - Solenoid Valve
 - 5 - Cane Carrier #2 Engine
 - 6 - Future Diaphragm Valve
 - 7 - Euclid Centrifugal Limit Switch
 - 8 - Future Euclid Centrifugal limit switch
in future set of knives
 - 9 - Cane Carrier #1 Engine
 - 10 - Emergency Double Pole Hand Switch
- J.M.C. - Oaklawn 1/15/71

THE FRENCH SCREW PRESS ON CUSH-CUSH

Report of the 1970 Crop Operation
W. Bradley Kimbrough
St. Mary Sugar Cooperative, Inc.

The easement of cane acreage restrictions during 1969 and 1970 enabled the members of St. Mary Co-op to produce more cane. In order to process the increased amount of member cane, St. Mary had alternatives of increasing daily grinding rate or increasing the length of the grinding season beyond 70 days. A grinding season of more than 70 days was deemed risky for present Louisiana conditions and increasing grinding rate without heavy capital investment seemed unlikely. The existing mill consisting of a 36" x 48" two roll crusher and six 28" x 48" mills was being operated at rates averaging over 3000 tons of cane per day which was well above the manufacturer's rated capacity of 1750 tons of cane per day.

A possible solution was discovered when tests conducted during the 1969 crop revealed that, on occasions, as much as 17 per cent of the total cane ground per day was being recycled through the mill by returning cush-cush to the second set of knives. It was proposed that removal of the cush-cush from the mill would result in a significant increase in mill grinding capacity. Through correspondence with the French Oil Mill Machinery Company, it was learned that a French press could be used to process cush-cush.

Development of using a French press for cush-cush began at the Lula factory in Louisiana around 1956. This was followed by further work at Okeelanta and Talisman in Florida. Pressing cush-cush was very successful at Talisman during the 1968-69 and 1969-70 crops, however, it was necessary to return pressed fiber to a later stage of the mill or to their final press due to a high residual sucrose and moisture content.

St. Mary and French Oil started a two crop program beginning with the 1970 crop to further develop the use of a French press for processing cush-cush. The goals set forth at the outset of the program were to press all cush-cush from the mill and send the fiber directly to the furnaces with a moisture and pol. content comparable to that of the mill bagasse and most importantly to increase the grinding rate by an amount equivalent to the cush-cush removed from the mill.

The cush-cush processing system is a two stage system consisting of a light duty press followed by a final press. This equipment was installed parallel to the mill at the same elevation as the mill walkway where the mill foreman station is located. After start up of the press drives the system was operated by the mill foreman. His primary duties were to take the system on and off the line and shut down the system during mill stops or in the case of equipment malfunction. Taking the system on and off the line is a simple matter and causes no lost time to the mill. A slide door operated by an air cylinder was installed in the bottom of the existing cush-cush drag and the control valve for the cylinder was located near the mill foreman's station. With the slide door closed cush-cush was returned to the second knives to be recycled through the mill. Opening the door allowed cush-cush to enter the press system.

The cush-cush flow and the counter-current maceration scheme are illustrated in Fig. 1. Cush-cush was handled with the conventional drag conveyor where juice was screened through the bottom. In the drag conveyor, the last juice to flood the cush-cush was the richest juice, that from the crusher, first and second mill. In order to displace the rich juice and enter the press system with lower sucrose, first press juice and second press juice were returned to the cush-cush drag for maceration.

After the two stage juice maceration, cush-cush was conveyed to the first press. The first press was used to remove excess juice and lower moisture to the 65-70 per cent range so that maceration water could be more effective. Maceration water was applied in the intermediate conveyor in approximately the same proportion as that used on the mill. It is important to note that using maceration water in the same proportion as that used on the mill does not increase the overall maceration water per cent cane. This follows, because had cush-cush gone through the mill it would have received it's fair per cent of water. If cush-cush is processed in the press system it still receives this same per cent and if an amount of cane equivalent to the cush-cush is added to the mill then no adjustment is necessary for the mill water. However, if additional cane is not added to the mill then mill maceration water should be reduced by the amount used in the cush-cush system.

The first press discharged cush-cush into the intermediate conveyor where maceration water was applied as described above and the cush-cush was conveyed to the second press. The cush-cush bagasse from the second press was discharged to a conveyor that added the bagasse to the mill bagasse going to the furnaces.

The light press is a model M-55 with overall dimensions of 2'-8" high, 2'-8" wide and 10' long. It is driven by a compact hydraulic motor which is powered by a 125 Hp electric motor driving a hydraulic pump. The unit is equipped with a load control to automatically adjust RPM for variations

in feed rate. The final press is a model L-77 with overall dimensions of 4'-9" high, 3'-2" wide, and 11' long. On the discharge end a hydraulic load cone and bracket extend 8' and on the feed end there is a large gearbox that is 3' by 5' and 6' high. This press is also equipped with a load control system to handle variations in feed rate. The drive is a 500 Hp steam turbine. The operating principle of both presses is the same. The material is fed to an enclosed screw that moves the material through successively smaller volume sections causing a compression of the material as it advances. Liquid drainage is through the cage that encloses the screw.

The primary purpose of the press installation was to increase mill grinding capacity. To insure that the 1970 grinding capacity without the press was representative, the grinding capacity of three previous crops was also determined. The criterion for this determination follows: 1) The maximum five day consecutive run for each crop was determined. A five day run was chosen so that reduced rates for evaporator cleaning would not be included. 2) The grinding rate for each five consecutive day run is an average of the tons of cane ground per grinding hour rather than tons of cane ground per crop day. This excludes mill lost time. These capacity determinations along with mill performance data are presented in Table 1. The 1970 average of 140 tons of cane per hour for five consecutive days is in line with the averages of the three previous years and should serve well as a measure of the mill grinding capacity without the press installation.

The maximum five consecutive day run with the press system in operation is compared to the maximum run without the press system in Table 2. During the run with the press system, the grinding rate increased from 140 tons of cane per hour to 158 tons of cane per hour or 12.85 per cent. During this run, lost time on the press system was 6 per cent, therefore, there would have been a greater increase had there been no lost time. On tons of cane per day this is an increase from 3360 tons to 3792 tons or 432 tons. It is interesting to note the differences in the mill performance during the two runs. However, more of the comparative runs are needed to draw firm conclusions. Some of the difference in in pol. extraction might be accounted for by the increase in pol. % cane during the run with the press system and the reduction in cane % fiber. It should be noted that since cane % fiber is a calculated figure, there is some question as to its validity.

While the run with the press system proved the principal of increasing grinding capacity by removal of cush-cush, press performance left room for improvement. The data for the press system operation during the run is presented in Table 3. Some of the high pol. in press bagasse can be attributed to the ineffectiveness of the juice maceration prior to the cush-cush entering the first press. Improvements for the 1971 crop which are still in the planning stages will add an additional maceration stage and possibly two. Also it is planned to bring moisture in first press bagasse down to the 60-65 per cent range. One maceration stage could be added by re-routing the crusher, first, and second mill juice canal up stream from the third mill canal. Another might be added by using all excess mill maceration juice that would ordinarily overflow to the dilute juice for cush-cush maceration. These improvements along with more effective application of the press juice maceration should reduce the amount of pol. entering the press system.

During the last three days of the maximum run with the press system, practically all pressure applied to the cone on the discharge end of the final press had to be relieved due to excessive loading of the press. Moisture and pol. content in bagasse went up immediately. Operating in this manner contributed to the high pol. in bagasse for the run. After the maximum run when the press system had been operated about eight days the cages were opened to find the reason for the excessive loading. Examination of the cages revealed the reason. The cage portion beneath each worm flight on the screw shaft particularly in the discharge end showed considerable wear. This wear condition was attributed to metal to metal contact between the worm flights and the cages rather than abrasion from cush-cush. To correct this situation and stabilize the screw shaft, a closer fitting center frame bushing was installed along with double flighted worms to relieve accentric loading. To further improve shaft stabilization, a supporting bearing is to be installed for the 1971 crop and all worms on the shaft will be double flighted with the exception of the feed worm.

After the changes to the screw and the reconditioning of the cages the press was put back on the line for the remaining twelve days of the crop. Data for this run is presented in Table 4 and a marked improvement can be noted. During this run there was no lost time attributed to either press. Unfortunately due to excessive mud which impaired bagasse burning and clarification the mill speed had to be reduced for all but two days of this last run. Even with mill speed reduced the average grinding rate for the twelve day run was 144 tons of cane per hour, which is an equivalent rate of 3456 tons of cane per day. Upon completion of the run the press was opened to check for wear. During the run the cush-cush contained a maximum amount of mud which should have produced the maximum abrasive characteristics. Examination of the cages and worm flights revealed that for all practical purposes there was no wear. The slight score marks present could have been due to start up and running the press while empty.

Some general comments on the operations with the screw press system should be in order at this point. The most significant bonus to the use of the system was improved bagasse burning. This could be attributed to the low moisture and high temperature of the press bagasse. These qualities actually helped mill bagasse burn. Also there was better drainage at the crusher as evidenced by the less frequent flow of juice over the top roll. Another benefit was removal of cush-cush during muddy conditions caused less mud to be recycled to the mill and reduced slip and wear on the mill.

On two occasions cane was taken from the second set of knives and processed by the press system. The cane was prepared prior to being pressed by two sets of knives only and the same maceration scheme as that used on cush-cush was used. The results presented below indicate that with some improvements primarily in maceration, cane could be processed in this manner.

Cane Processed by French Press System

Date	% Pol.	% Moist.
12-24	4.49	44.00
12-28	4.21	48.00

The press system installed at St. Mary has capacity for handling more than the amount of cush-cush produced. The results of the tests above indicate that it might be possible to divert some cane from the mill in addition to the cush-cush and do satisfactory work. If this could be accomplished a capacity increase in excess of the 12.85 per cent achieved during the 1970 crop would be realized.

Removal of cush-cush from the mill can produce a significant improvement in mill grinding capacity. For those mills wishing to maximize existing mill trains in order to increase production, the French screw press or other systems for processing cush-cush deserve consideration.

TABLE 1

Maximum Five Consecutive Day Run and Mill Performance

Year	Tons Per Hour	Equivalent Tons Per Day	<u>Bagasse</u>		Cane % Fiber	Pol. Extract
			% Pol.	% Moist.		
1970 12/3-12/7	140	3360	2.89	50.60	14.97	90.94
1969 12/1-12/5	139	3336	3.30	51.63	12.04	92.11
1968 11/25-11/29	143	3432	3.00	50.55	15.87	89.75
1967 12/12-12/16	141	3384	3.17	50.15	17.01	88.30

TABLE 2

Comparison of Maximum run with Press System and Without Press System

Year	Tons Per Hour	Equivalent Tons Per Day	<u>Bagasse</u>		Cane		Pol. Extract
			% Pol.	% Moist.	% Pol.	% Fiber	
1970 12/3-12/7	140	3366	2.89	50.60	10.49	14.97	90.94
1970 12/8-12/12	158	3792	3.16	51.54	11.00	11.81	92.23

TABLE 3

Press System Performance Data for Maximum Run

<u>First Press</u>		<u>Second Press</u>	
% Pol.	% Moist.	% Pol.	% Moist.
7.14	67.45	4.53	47.51

TABLE 4

PRESS PERFORMANCE DATA FOR FINAL RUN

<u>First Press</u>		<u>Second Press</u>	
% Pol.	% Moist.	% Pol.	% Moist.
6.24	66.24	3.87	50.60

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CONSTITUTION OF THE
AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS
(As amended and restated February 5, 1970)

ARTICLE I

Name, Object and Domicile

Section 1. The name of this Society shall be the American Society of Sugar Cane Technologists.

Section 2. The object of this Society shall be the general study of the sugar industry in all its various branches and the dissemination of information to the members of the organization through meetings and publications.

Section 3. The domicile of the Society shall be at the Louisiana State University and Agricultural and Mechanical College, Baton Rouge, Louisiana, USA.

ARTICLE II

Divisions

The Society shall be composed of two divisions, the Louisiana Division and the Florida Division. Each division shall have its separate membership roster and separate officers and committees. Voting rights of active members shall be restricted to their respective divisions, except at the general annual and special meetings of the entire Society, hereinafter provided for, at which general meetings active members of both divisions shall have the right to vote. Officers and committeemen shall be members of and serve the respective divisions from which elected or selected, except the General Secretary-Treasurer who shall serve the entire Society.

ARTICLE III

Membership and Dues

Section 1. There shall be five classes of members: Active, Associate, Supporting, Honorary and Off-shore or Foreign.

Section 2. Active members shall be individuals residing in the continental United States actually engaged in the production of sugar cane or the manufacture of cane sugar, or research or education pertaining to the industry, including employees of any corporation, firm or other organization which is so engaged.

Section 3. Associate members shall be individuals not actively engaged in the production of sugar cane or the manufacture of cane sugar or research pertaining to the industry, but who may be interested in the objects of the Society.

Section 4. Supporting members shall be persons engaged in the manufacturing, production or distribution of equipment or supplies used in conjunction with production of sugar cane or cane sugar, or any corporation, firm or other organization engaged in the production of sugar cane or the manufacture of cane sugar, who may be interested in the objects of the Society.

Section 5. Off-shore or Foreign members shall be individuals not residing in the Continental United States who may be interested in the objects of the Society.

Section 6. Honorary membership shall be conferred on any individual who has distinguished himself in the sugar industry, and elected by a majority vote of the Joint Executive Committee. Honorary members shall be exempt from dues and entitled to all the privileges of active membership.

Section 7. Applicants for membership shall make written application to the Secretary-Treasurer of the respective divisions, endorsed by two active members of the division, and such applications shall be acted upon by the division membership committee.

Section 8. Annual dues shall be as follows:

Supporting Membership -----	\$30.00
Associate Membership -----	\$15.00
Off-shore or Foreign Membership -----	\$10.00
Active Membership -----	\$ 5.00
Honorary Membership -----	NONE

Dues for each calendar year shall be paid not later than December 1 of such year. New members shall pay the full amount of dues, irrespective of when they join.

Section 9. Dues shall be collected by each of the Division Secretary-Treasurers from the members in their respective divisions. Unless and until changed by action of the Joint Executive Committee, 30% of all dues collected shall be transmitted to the office of the General Secretary-Treasurer.

Section 10. Members in arrears for dues for more than a year will be dropped from membership after thirty days notice to this effect from the Secretary-Treasurer. Members thus dropped may be reinstated only after payment of back dues and assessments.

Section 11. Only active members of the Society shall have the privilege of voting, holding office and initiating discussion from the floor at division and general meetings.

ARTICLE IV

General Secretary-Treasurer and Joint Executive Committee

Section 1. The General Secretary-Treasurer shall serve as Chief Administrative Officer of the Society and shall coordinate the activities of the divisions and the sections. He will serve as ex-officio Chairman of the Joint Executive Committee and as General Chairman of the General Society Meetings, and shall have such other duties as may be delegated to him by the Joint Executive Committee. His office shall be at the domicile of the Society.

Section 2. The Joint Executive Committee shall be composed of the members of the two division Executive Committees, and is vested with full authority to conduct the business and affairs of the Society.

ARTICLE V

Division Officers and Executive Committee

Section 1. The officers of each division of the Society shall be: A President, a First Vice-President, a Second Vice-President, a Secretary-Treasurer, and an Executive Committee composed of these officers and three other members, one from each Section of the Division (as described in Section 3 of Article VII) and one elected at large.

The Ex-President shall serve as an Ex-Officio member of the Division Executive Committee for one year following his term of office.

Section 2. These officers, except Secretary-Treasurer, shall be nominated by a nominating committee and voted upon before the annual division meeting. Notices of such nominations shall be mailed to each member at least one month before such meeting. Ballots not received before noon of the Saturday preceeding the first day of the meeting will not be counted.

Section 3. The Secretary-Treasurer shall be appointed by and serve at the pleasure of the Division Executive Committee.

Section 4. The duties of these officers shall be such as usually pertain to such officers in similar societies.

Section 5. Each section as described in Article VII shall be represented in the offices of the President and Vice-President.

Section 6. The officers of the Division shall hold office for one year only, or until their successors shall be elected.

Section 7. No one may be elected President of the Division for two consecutive years.

Section 8. The President shall be elected each year alternately from the two sections hereinafter provided for. The President for each Division shall be nominated and elected from a different Section. The President from the Louisiana Division for the year beginning February, 1970, shall be nominated and elected from the Agricultural Section. The President from the Florida Division for the year beginning February, 1970, shall be nominated and elected from the Manufacturing Section.

Section 9. Vacancies occurring between meetings shall be filled by the Division Executive Committee.

Section 10. The terms "year" and "consecutive year" as used in Articles V and VI shall be considered to be comprised of the elapsed time between one annual division meeting of the Society and the following annual division meeting of the Society.

ARTICLE VI

Division Committees

Section 1. The President of each division shall appoint a committee of three to serve as a Membership Committee. It will be the duty of this committee to pass upon applications for membership in the division and report to the Secretary-Treasurer.

Section 2. The President of each division shall appoint each year a committee of three to serve as a Nominating Committee. It will be the duty of the Secretary of the Division to notify all active members of the Division as to the personnel of this committee. It will be the duty of this committee to receive nominations and to prepare a list of nominees and mail this to each member of the Division at least a month before the annual division meeting.

ARTICLE VII

Sections

Section 1. There shall be two sections of each Division, to be designated as:

1. Manufacturing
2. Agricultural

Section 2. Each active member shall designate whether he desires to be enrolled in the Manufacturing Section or the Agricultural Section.

Section 3. There shall be a Chairman for each Section of each Division who will be the member from that Section elected to the Executive Committee. It will be the duty of the Chairman of a section to arrange the program for the annual Division meeting.

Section 4. The Executive Committee of each Division is empowered to elect one of their own number or to appoint another person to handle the details of printing, proof reading, etc., in connection with these programs and to authorize the Treasurer to make whatever payments may be necessary for same.

ARTICLE VIII

Meetings

Section 1. The annual General Meeting of the members of the Society shall be held in June each year on a date and at a place to be determined, from time to time, by the Joint Executive Committee. At all meetings of the members of the Society 5% of the active members shall constitute a quorum. The program for the annual meeting of the Society shall be arranged by the General Secretary-Treasurer in collaboration with the Joint Executive Committee.

Section 2. The annual meeting of the Louisiana Division shall be held in February of each year, at such time as the Executive Committee of that Division shall decide. The annual meeting of the Florida Division shall be held in October of each year, at such time as the Executive Committee of that Division shall decide. Special meetings of a Division may be called by the Executive Committee of such Division.

Section 3. Special meetings of a Section for the discussion of matters of particular interest to that Section may be called by the President upon request from the respective Chairman of a Section.

Section 4. At Division meetings, ten percent of the active division members and the President or a Vice-President shall constitute a quorum.

ARTICLE IX

Management

Section 1. The conduct and management of the affairs of the Society and of the Divisions including the direction of work of its special committees, shall be in the hands of the Joint Executive Committee and Division Executive Committees, respectively.

Section 2. The Joint Executive Committee shall represent this Society in conferences with the American Sugar Cane League, the Florida Sugar Cane League, or any other association, and may make any rules or conduct any business not in conflict with this Constitution.

Section 3. Four members of the Division Executive Committee shall constitute a quorum. The President, or in his absence one of the Vice-Presidents, shall be Chairman of this committee.

Section 4. Two members of each Division Executive Committee shall constitute a quorum of all members of the Joint Executive Committee, and each Division shall be entitled to one vote, regardless of the number of committee members present.

ARTICLE X

Amendments

Section 1. Amendments to this Constitution may be made only at the annual meeting of the Society or at a special meeting of the Society. Written notices of such proposed amendments, accompanied by the signature of at least twenty (20) active members must be given to the General Secretary-Treasurer at least thirty (30) days before the date of the meeting, and he must notify each member of the proposed amendment before the date of the meeting.

Section 2. Amendments shall be adopted by a two-thirds majority of those voting.







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PROCEEDINGS

**American Society
of
Sugar Cane Technologists**

1972 MEETINGS

Volume 2 (New Series)

Florida and Louisiana Divisions



July 1973

PROCEEDINGS
AMERICAN SOCIETY
OF
SUGAR CANE TECHNOLOGISTS

Florida and Louisiana Divisions

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July 1973

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FOREWORD

Attention of the membership of ASSCT and other readers of the Proceedings of this organization is directed to the fact that beginning with the Proceedings for the 1971 meetings and continuing with the current set a new series of volume numbers has been adopted in order to distinguish the proceedings published after reorganization of ASSCT into two divisions from those preceding this reorganization. In continuation of this procedure, the current issue is designated Volume 2, with the words New Series added to avoid confusion with earlier volumes. Please note the standard form adopted in citing references from the New Series by examining the References lists at the end of some of the papers in the current volume.

Attention is also called of all members to the new editorial policy that has been developed by the Editorial Committee. The new policy is published in the current volume of the Proceedings. The Society is indebted to the members of the Editorial Committee for providing an improved editorial style and procedure for the ASSCT Proceedings. If all authors of papers will cooperate earnestly in following the guidelines, the Proceedings will represent a more valuable and prestigious publication.

M. T. Henderson
Editor

OFFICERS AND COMMITTEES FOR 1972

General Officers and Committees

General Secretary-Treasurer
Denver T. Loupe

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General Editor - M. T. Henderson

Program Chairman
Norman I. James

Associate Editors
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Engineering - Darrell L. Roberts
Entomology - Sess D. Hensley
Manufacturing -
William J. Baptiste (Florida)
W. Bradley Kimbrough (Louisiana)
Pathology-Physiology - G. T. A. Benda
Soil Fertility - Garry J. Gascho

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James E. Irvine
W. Bradley Kimbrough
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R. J. Matherne
Pete McIntyre
Jack Martinez
Connie Melancon
Charles Savoie

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Florida

Office

Louisiana

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Pete McIntyre
John Boy
Ray Walker
Rafael Fanjul
Stanley Hooks
Leo P. Hebert
Charles Freeman

President
1st Vice President
2nd Vice President
Chairman Agriculture Section
Chairman Manufacturing Section
Chairman At Large
Immediate Past President
Secretary-Treasurer

James E. Irvine
Connie Melancon
Kermit Coulon
R. J. Matherne
W. Bradley Kimbrough
Charles Savoie
F. A. Graugnard, Jr.
Denver T. Loupe

Program of Second Annual Joint Meeting
Pensacola, Florida
June 8 - 9, 1972

June 8
Morning Session

Registration

Plenary Session

Welcome

James E. Irvine
President, Louisiana Division
Jack L. Martinez
President, Florida Division

Report of General Secretary-Treasurer
Denver T. Loupe

Report on 14th Congress, ISSCT
Denver T. Loupe
Charles E. Freeman

General Business

Afternoon Session

Joint Meeting of Agricultural and Manufacturing Sections

Chairman: R. J. Matherne
Papers:

Activities of the Cane Sugar Refining Research Project - F. G. Carpenter and
Margaret A. Clarke

The History and Development of Sugar Yield Calculations - B. L. Legendre and
M. T. Henderson

Cane Grinding and the Changing Times in the Everglades - P. J. Thielen

The Fourth Phase Which Affected the Long Term Successful Founding of the Florida Cane
Sugar Industry - B. A. Bourne

Testing of Sugarcane Varieties for Milling Quality - L. P. Hebert

Demonstrated and Potential Control of Sugarcane Borer in Florida by the Cuban Fly,
Lixophaga diatraeae - T. E. Summers and R. D. Jackson

Effect of Some Soil Pesticides on Sugarcane Yields in Florida - H. H. Samol and
S. R. Johnson

Soil-incorporated Trifluralin for Controlling Weeds in Sugarcane - R. W. Millhollon

The Effect of Agricultural Lime and Ground Rock Phosphate on Yield of Sugarcane Soil pH,
and P and Ca Extractable from Baldwin Silty Clay Loam Soil - Laron E. Golden

June 9
Morning Session

Agricultural Section

Chairman: Ray L. Walker
Papers:

✓ The Use of Programming Calculators in Sugarcane Breeding - J. D. Miller and N. I. James

• The Out-of Season Flowering of Sugarcane and Its Significance for Breeding -
E. D. Paliatseas

✓ Selecting Commercial Sugarcane Varieties from Large Seedling and Clonal Populations -
R. D. Breaux

Increasing Frequency of High Sucrose CP Varieties - R. J. Matherne

Sugarcane Variety Testing at the Outfield Level in Louisiana - H. P. Fanguy and
Mike J. Giamalva

Canopy Characters and Their Relation to Yield of Sugarcane Varieties - James E. Irvine

Maize Dwarf Mosaic Virus Susceptibility in Parental Lines of Sugarcane - A. G. Gillaspie,
Jr. and H. Koike

Sugarcane Mosaic Virus Transmission Studies with the West Indian Sugarcane Fulgorid -
H. Koike and L. J. Charpentier

The Ratoon Stunting Disease and Growth: Single-Rooted Plants of Sugarcane and of
Sudangrass Hybrid - G. T. A. Benda

Growth of Sugarcane: Effects of 2 Soil Fungi - Shaw Ming Yang

Relative Pathogenicity of Isolates of Colletotrichum falcatum on Sugarcane Seed Pieces -
Donald B. Fontenot, Mike J. Giamalva, and Donald J. Chiasson

Manufacturing Section

Chairman: Rafael Fanjul

Papers:

Corrosion Fatigue: Its Effect on Sugarcane Chain Conveyors - J. H. Shuler,
Preston Guillotte, and Robert Harper

Polymer Flocculants in Mud Filtration - James C. P. Chen and Robert W. Picou

Cleaning and Maintenance of Heating Surfaces in Vacuum Pans and Evaporators -
Blas M. Rodriguez

Comprehensive Study of Florida Boiling Systems - Jose J. Balerdi

Presence of Non-Sucrose Polysaccharides in Sugarcane Juice and Its Influence on Sugar
Recovery - Carlos R. Toca

The Use of a 30,000 Ton Sugar Silo in the Moore Haven Sugar House - Myron H. Caplin

Handling of C Sugar Excess - Armando A. Acosta

Performance of the Screw Press at Cora-Texas Sugar Factory, White Castle, La. -
John Engolio, Jr. and Jose G. Spinoso

Rotary Coil Heat Exchange Element for Crystallizer - P. F. Triviz

June 9

Afternoon Session

Joint Meeting of Agricultural and Manufacturing Sections

Chairman: Bradley Kimbrough

Address: The Honorable Patrick T. Caffery, U. S. Congressman, Louisiana

Papers:

Boiler Stack Emission - Clewiston Sugar House - Ben F. Sanford, Jr.

Air and Water Environmental Control in the Cane Sugar Industry - F. A. Grillot, Jr.

Cleaning Sugarcane During Harvest: Cleaning Rolls or Pneumatics - Joe E. Clayton
and Donald B. Churchill

A Cost Analysis of Toft Mechanical Harvesting in Zone 5 of Talisman Sugar Corporation -
Raymond L. Walker

Experimental 2-Machine Approach to Sugarcane Harvesting in Florida - Larry G. Fowler

Two-Row Sugarcane Combine - Rafael Fanjul and Isby Schexnayder

Program of Third Annual Florida Division Meeting
Clewiston, Florida
October 12, 1972

Registration

Welcome

Jack A. Martinez
President, Florida Division

Manufacturing Section

Chairman: Rafael Fanjul
Papers:

Viscosity - Guillermo Aleman

Second Report on the Experimental Cush-Cush Screw Press Operation at Bryant Sugar House -
Ernesto del Valle

Cleaning and Maintenance of Heating Surfaces in Vacuum Pans and Evaporators -
Blas M. Rodriguez

Panel Discussion: Occupational Safety Health Act - Rafael Fanjul (Moderator), Christopher
Davison, Malcolm Smith, Nick Smith, and Bob Thompson

Agricultural Section

Chairman: Ray L. Walker
Papers:

Sugarcane Deterioration During Storage as Affected by Chopping, Delay in Milling, and
Burning - G. J. Gascho, J. E. Clayton, and J. P. Gentry

A Preliminary Row-Spacing Experiment with Sugarcane in Florida - E. R. Rice

✓ The Sugarcane Variety Development Program at the Agricultural Research and Education Center,
Belle Glade - Charles E. Freeman and Ray L. Walker

Developments in Sugarcane Planting at Sugar Cane Growers Cooperative of Florida -
Larry G. Fowler

Planting Methods: Summary of Panel Discussion - Ray L. Walker

Program of 1972 Annual Meeting of Louisiana Division
Baton Rouge, Louisiana
February 3, 1972

Registration

Call to Order

F. A. Graugnard
President, Louisiana Division

Manufacturing Section

Chairman: Octave Gutekunst
Papers:

Status of the Development of a Wholestalk Cane Cleaner - Darrell L. Roberts

Cane Juice Acidity vs Sugar Recovery - James C. P. Chen and Robert W. Picou

Why? - F. A. Graugnard, Jr.

Performance of the Screw Press at Cora-Texas Sugar Factory - Jose G. Spinosa

The 1971 Crop Audubon Sugar Factory Studies - John J. Seip and Fred L. Gayle

Agricultural Section

Chairman: Kermit J. Coulon

Papers:

✓ Higher Sugarcane Yields Through Higher Populations - R. J. Matherne

Farm Safety - William Hadden

Hot-Water Treatment for Mosaic and Ratoon Stunting Disease Control - G. T. A. Benda

Report on 14th Congress of ISSCT - Denver T. Loupe

Business Meeting

Address: Paul W. Murrill, Provost and Vice-Chancellor for Academic Affairs, Louisiana
State University

Papers Presented at
Second Annual Joint Meeting

Pensacola, Florida
June 8 - 9, 1972

ACTIVITIES OF THE CANE SUGAR REFINING RESEARCH PROJECT

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ABSTRACT

The Cane Sugar Refining Research Project is an organization of sugar refiners that cooperates with USDA in conducting research on sugar refining problems. The work is at the level of 3 senior scientists plus supporting personnel. One of the current topics of research is identification of the sugar colorant. In this, there has been considerable success in that 23 specific compounds have been identified. Another topic concerns the various reactions of calcium with sugar constituents, including sucrose. A better understanding of these reactions is needed to explain and possibly improve the clarifying action of lime.

INTRODUCTION

The Cane Sugar Refining Research Project is an organization of sugar refiners and suppliers to the industry from all over the world, which was organized to conduct research on sugar refining problems in cooperation with the USDA. It is the successor to the former Bone Char Project at the National Bureau of Standards. Together the 2 organizations have been in operation since 1939, and represent 33 years of cooperative research between the sugar refining industry and the US Government.

At present, a little over half of the effort is supplied by the industry, which uses all its funds to hire 4 research workers. The USDA supplies 1 worker, laboratory space at the Southern Regional Research Laboratory in New Orleans, and supervision. The team consists of 3 senior scientists and supporting personnel.

Since the sponsors are sugar refiners, the research program is concerned primarily with refining problems. However, sugar refining is a highly competitive business, and, since nobody wants to help solve all his competitor's problems, and since each refiner has a good engineering and development department, the work is primarily directed toward fundamental research.

The fundamental problems of refining are usually related to raw sugar manufacture, agricultural operations, and even cane breeding. So the research is really for the benefit of the whole sugar industry.

IDENTIFICATION OF COLORANT

In chemical engineering parlance, the KEY component in cane sugar processing is color. If color is brought to a satisfactory level in the final refined product, then usually all other components will also be within specifications. As a result, almost every refinery is operated using color as the primary control.

In spite of the fact that color has been used as the control for years, nobody knows what the color really is. It is well recognized that the color is caused by many different colored chemical materials, and one of the major research efforts of this project is to identify some of these colorants.

For classification purposes the colorants are divided into 3 groups: those derived from decomposition of sucrose (caramel), those formed by reaction of uncolored constituents such as amino acids + reducing sugars to give melanoidins, and plant pigments.

Considerable success has been achieved using high voltage paper electrophoresis as developed by Gross (6, 7) as the principal method to separate individual colorants. This chromatographic-type analytical method easily separated the sugar colorant into more than 30 fractions, 23 of which have now been identified in our research work.

Before any of the components had been identified, their progress had been traced from cane juice to refined sugar (5) to determine which components were removed at which stage in the processing. This is summarized in Table I.

Table I. Colorants in cane sugar

Spot no.		Cane juice	Raw sugar	Refined sugar	Compound
Original	Found later				
	-5				coumarin
	-3				coniferin
1		X	X		Kaempferol
2		X			
3		X	X		quercetin
4		X	X		
5		X		X	
6		X	X		
7		X			
8		X			
9		X	X	X	esculin
10		X	X	X	rutin
11		X	X		
12	11.5	X	X		7-hydroxycoumarin
	12.1	X	X	X	
13		X	X	X	4-hydroxy-3,5-dimethoxycinnamic acid
	13.9				4-hydroxy-3,5-dimethoxycinnamic acid
14		X	X	X	3,4-dihydroxybenzaldehyde
	14.9				4-hydroxy-3-methoxycinnamic acid
15		X	X	X	4-hydroxy-3-methoxybenzaldehyde
	15.6				chlorogenic acid
16		X	X		4-hydroxy-3-methoxycinnamic acid
17		X			
	17.1				4-hydroxy-3,5-dimethoxybenzoic acid
18		X	X		p-hydroxybenzaldehyde
19		X			
20		X		X	
21		X	X		p-hydroxycinnamic acid
	21.1				p-hydroxycinnamic acid
22		X			4-hydroxy-3-methoxybenzoic acid
	22.1				3,4-dihydroxycinnamic acid
23		X	X		p-hydroxybenzoic acid
24		X	X		3,4-dihydroxycinnamic acid
	24.9				3,4-dihydroxybenzoic acid
25		X			
26		X			
27		X			
28		X	X	X	aconitic acid, and fumaric acid

The colorants were originally identified only by spot number, i.e., the position of individual fractions, on the high voltage paper electrophorogram. The 1st 5 columns of Table 1 show how the "spots" progress through the processing. Upon further examination some spots were found in between the original spot numbers and these were given fractional numbers.

Most of the spots, but not all, were found in cane juice, suggesting that these particular colorants were plant pigments. This was later found to be indeed the case. Some of the spots disappear in raw sugar but are found again in refined sugar. This can be explained by their being the breakdown products of more complex substances, which survive the sugar mill but break down in the refinery.

The first substance identified (2) was spot number 15. This spot was in all sugar products, and by chance was found to be particularly prevalent in coffee. A check of the known constituents of coffee suggested chlorogenic acid, which was soon proved to be the substance found in sugar. Chlorogenic acid is a plant pigment, found in cane leaves (8). It is related to disease resistance in some plants. It was thought likely that some of the other spots were of the same general family as chlorogenic acid; therefore, the whole family of cinnamic acid derivatives (of which chlorogenic acid is one) and related compounds was checked. Upon comparison with known compounds, many other spots were identified. All of these materials were in the plant pigment category and in the class commonly called phenolics or polyphenols. These polyphenolic compounds are found in many plants, especially grasses.

All of these materials were identified only by chromatographic-type means, using at least 4, and preferably more, very different systems to match each unknown with samples of known compounds. The systems used were high voltage paper electrophoresis, gas liquid chromatography, and thin layer chromatography (with various solvent systems) (3, 4).

The last column in Table 1 gives the chemical name of the identified components. Several of the names appear twice: these are cis- and transisomers, which can be separated by high voltage paper electrophoresis in some cases. One spot (no. 28) contains 2 components; these were separated by some of the other chromatographic schemes. The term components is used instead of colorants because some of the compounds are not colored. However, color as used in the sugar industry has always meant impurities, and all these components are impurities, i.e., non-sucrose compounds.

Several of these components had been previously detected in sugar, but they are included here to show how they fit into this scheme of classification. These components represent only part of the sugar colorant. The whole classes of caramels and melanoidins are still untouched, and some of the as yet unidentified electrophorogram spots may be in these classes. The work so far has been concerned with identifying the components. At present, gas-liquid chromatography is being used both to separate and identify other components, and to quantitize the amounts of various components present. GLC can separate about 80 component peaks, some of which are probably caramels and melanoidins. The colored components are present in the sub ppm range in both raw and refined sugars.

PHYSICAL CHEMISTRY STUDIES

Another major area of research of the project is the physical chemistry of refining processes, particularly clarification processes. The formation of calcium phosphate precipitates is being investigated using the recently introduced Ca ion-selective electrode to follow changes in Ca ion activity. In an examination of these electrodes, it was found that they can also be used to monitor Ca ion in process liquors, under certain conditions; e.g., the electrodes cannot be used above 50 C. (1). They are a good method of end-point determination in Ca titration determinations.

The structure of sugar-water solution mixtures is being studied with regard to its effect on electrode readings in concentrated sugar solutions (1). Findings in this area will be applied to the work on clarification mechanisms and to other refinery processes, such as absorption.

At present, the clarification studies are only on calcium phosphates; these will be extended to look at calcium carbonates. A great deal of the fundamental chemistry here is the same as that for the lime process used in sugar milling. The work on structure of sugar solutions is likewise relevant to all stages of sugar processing, including crystallization.

The presence of heavy metals in sugars is also under investigation, in cooperation with one of the refinery sponsors. Occasionally the Project undertakes this type of cooperative investigation with one or more of the sponsors.

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THE HISTORY AND DEVELOPMENT OF SUGAR YIELD CALCULATIONS

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ABSTRACT

The amount of sucrose that can be obtained from a ton of sugarcane is a basic component of the yield of sugar per acre. A simplified method for making theoretical sugar yield calculations for field trials was first described in 1933. It required only the analysis of the primary or crusher juice for brix and sucrose (pol). Later, comparative mill tests to distinguish varietal differences in milling quality were integrated into the method. This improved method for calculating sugar yields allows for rapid determination of a large number of field samples and makes appropriate allowances for varietal differences in milling quality. This paper traces the history of sugar yield calculations, examines and tests the development and applicability of the formula under current conditions and suggests possible improvements in the present system.

Sugar per unit area of land is the ultimate criterion of sugarcane production. It is dependent upon 2 general constituents: 1) amount of cane per unit area of land and 2) amount of sucrose in that cane. Agronomists measure the amount of cane produced by weighing plots or samples. On the other hand, measuring the amount of sucrose in cane is not so simple. It involves a complex procedure of chemical laboratory analyses and sophisticated calculations.

Normally, the sugar chemist's job is completed once he has reported the sucrose content of the juice sample. The agronomist must then convert his data and that of the chemist into the amount of sugar per unit area of land. The novice might think that this can be done using simple arithmetic. He knows the weight of cane in the field, he takes a sample of cane, weighs that, crushes it and weighs the juice and has the chemist determine the weight of sucrose in the juice. He decides that sugar per unit area (S_a) is the product of the weight of cane per unit area (T) and the percent sugar in cane (S_c), or

$$I \quad S_a = TS_c.$$

The percent sucrose in cane can be calculated by multiplying the juice weight (W_j) by the percent sucrose in the juice (S_j) (chemists's data) and dividing the product by the weight of the cane sample (W_c), or

$$S_c = \frac{(W_j) (S_j)}{W_c}, \text{ or}$$

finally,

$$II \quad S_a = T \frac{(W_j) (S_j)}{W_c}$$

This approach to calculating sugar yields per unit area of land would invariably result in a large overestimation. The weight of net cane is influenced only by the amount of extraneous material present. However, there are several variables which affect the yield of sugar. The causes of error in this calculation form the text of this paper.

Errors occur in sampling sugarcane juices. Normal juice (absolute juice) represents juice as it occurs in the cane. Normal juice values are theoretical but may be approximated by multiple milling. This is a tedious process and large numbers of samples are routinely analyzed by assaying crusher juice (juice from a single milling with 2 rolls). Crusher juice does not represent the normal juice; crusher juice sucrose is usually higher. When crusher juice is used in sugar yield calculations it is necessary to apply reduction factors. These factors reduce the brix and sucrose of the crusher juice to that of normal juice.

In Java it was recognized for the variety Cheribon (La. Purple) that, in general, normal juice contained 85% of the sucrose of crusher juice (12,13). To compute sucrose in normal juice, it was proposed that crusher juice sucrose values be multiplied by 0.85 to reduce them to normal juice values. Following the development of new varieties, it was found that this factor was no longer valid (10). Arceneaux (7, 9, 14) found significant differences between varieties in sucrose reduction factors in Louisiana and computed separate values for each variety. The relationship of the sucrose reduction factor for a variety from test to test was consistent.

Deere (10) used a factor of 0.97 to reduce the brix of the crusher juice to the brix of normal juice. This value is still used by commercial mills in Louisiana in their factory control. However, in 1933, Arceneaux (9) proposed that a factor of 0.985 be used for all varieties in experimental work to reduce the brix of the crusher juice to normal juice. Though he found significant differences among varieties in their brix reduction factors, he felt that the small differences did not warrant separate computations for each variety. Differences in sugar per ton of cane caused by differences in brix reduction factors are slight and are less than those caused by experimental and biological errors.

Arceneaux (4) stated that by not controlling varietal differences in reduction factors (brix and sucrose) an error of 2.4 - 4.1 lb of 96° (pol) sucrose per ton of cane was obtained between varieties. However, these differences were noted as being primarily caused by the variations in the sucrose reduction factors.

Sucrose is reported by commercial mills as raw sugar, not pure sucrose. Raw or 96° sucrose is an intermediate product of pure sucrose crystals coated by a film of low quality syrup. The sucrose content of cane is calculated and expressed as the weight of sugar determined by dividing the weight of its sucrose content by 96% (2, 16). To report sucrose on the basis of 100 pol would underestimate the yield of the raw sugar product.

Reduction factors reduce the brix and sucrose of the crusher juice to normal juice. However, before the amount of sugar in cane can be computed, the amount of normal juice that can be extracted from the cane under routine milling operation must first be determined. Arceneaux (9) indicated that prior to 1933 arbitrary juice extraction figures were assigned to new clones based on the performance of a certain mill. He recognized that with the great number of experimental clones in the early stages of field testing, there was not enough cane to conduct milling tests with factory equipment to measure differences which might exist between varieties.

In early mill tests at Houma, small quantities of sugarcane were milled under carefully controlled conditions. These tests were with 2 experimental mills. The first, designated mill no. 1, was power-driven but not equipped with a hydraulic system. This mill was used for all routine milling of cane samples and gave approximately 60% juice extraction with Co 281. The second, designated mill no. 2, was power-driven with a hydraulic system to maintain approximately 30 tons pressure on the top roll. Both mills had 3-rolls (3, 9). Today, a complete mill test involves the milling of an 80 lb, hand cleaned sample of cane 4 times through a single 3-roller (10 x 14-in. rolls) hydraulic mill with approximately 30 tons pressure exerted on the top roller. Cold maceration water (water added to bagasse to increase sucrose extraction) is sprinkled on the bagasse after each of the last 3 millings. The water, 20% by weight of sample, is applied in 3 equal portions; an 80 lb sample receives 5.33 lb 3 times.

Data obtained from a complete milling test are as follows: 1) crusher juice weight, brix, and sucrose; 2) mixed juice weight, brix and sucrose (mixed juice is juice from the last three millings and includes part of the maceration water); and 3) bagasse weight and fiber percent bagasse. Using this data, the normal juice extraction and the sucrose reduction factor are computed. Arceneaux (4) indicated that the error in calculated sugar yields due to varietal differences in normal juice extraction ranged from 8.5 - 18.6 lb of 96° sugar per ton of cane.

The yield of sugar with a given crusher juice analysis depends upon 3 factors: 1) brix reduction factor; 2) sucrose reduction factor; and 3) normal juice extraction. Failure to correct for brix and sucrose reduction factors and normal juice extraction under experimental conditions gave systematic errors ranging from 12.6 - 22.2 lb of 96° sugar per ton of cane (4).

Arceneaux (3, 4, 5, 9, 14) was interested in combining the effects of these 3 varietal influences. Using POJ 213 as the standard, the combined effect of these 3 variables was reduced to a single factor, designated as the varietal correction factor (VCF). Later, he substituted Co 281 as the standard variety. He assigned correction factors to new varieties by comparing them to Co 281 with a VCF set arbitrarily at 1.00. The yield of sugar per ton of cane was first determined for each variety based on milling results obtained in a test. A corresponding set of yield figures was determined by applying to the crusher juice analysis of each variety, the percent juice extraction and reduction factors observed for Co 281 in the same test. A VCF was then determined for each variety by dividing the yield of sugar per ton of cane based on actual milling results by the corresponding yield based on Co 281 milling factors.

Varietal differences in milling quality revealed by experimental mill tests are broadly representative (4, 5, 9). Even though VCF's apply specifically to conditions under which the mill tests are conducted, such factors can be applied with reasonable accuracy to correct the varietal differences in milling qualities.

Further milling tests were conducted by Arceneaux (3) in an attempt to determine the effect of additional variables on varietal milling qualities. He found a highly significant variety effect but no differences between crops (plant and stubble), years, or dates of harvest. These results indicated that a VCF for any given variety approximated a constant. Arceneaux (3, 9) stated that the use of appropriate generalized factors should permit an unbiased determination of sugar yields from the usual analytical results obtained in connection with variety tests.

However, use of the combined factor tends to give an overestimation of sugar yield. The overestimation is due to several factors. Cane samples used in these tests are free of trash and this promotes better normal juice and sucrose extraction. The resulting better juice extraction would minimize the differences between quality of crusher and normal juice. The resulting reduction factor would be less than that obtained for cane containing trash, and sucrose yield would be overestimated. Arceneaux stated that his juice extraction values from complete milling tests were higher than expected under typical factory conditions in Louisiana. In his initial crushing, more juice was removed than expected by commercial factory crushers.

Once the juice has been extracted from the cane, it is transported to the boiling house where the raw juice is processed into sucrose. Failure to consider the boiling house operation can lead to serious error when making sugar yield calculations.

The amount of sucrose recoverable from cane is influenced not only by the amount of sucrose present in the raw juice but also by the amount and composition of non-sucrose solids (reducing sugars, ash, and organic non-sugars) present. Winter (12)^{1/} observed actual mill performance of several factories in Java and in 1897 proposed the following formula:

III

$$x = S (1.4 - 40/P)$$

where x = available sucrose percent cane, S = percent sucrose in the juice in terms of the weight of cane, and P = purity of the juice. The formula was derived from the relationship that as an average each pound of non-sucrose solids prevented the crystallization of 0.4 lb of sucrose in the final molasses. Using this relationship, the formula is based on a molasses purity of 28.57, i.e., $(0.4 + 1.4) \times 100 = 28.57$ (17).

Arceneaux (2) realized the need to adjust for non-sucrose solids in the juice, and simplified the formula of Winter to read:

IV

$$S = s [(0.4) (b - s)]$$

where S = recoverable sucrose in a given weight of juice extracted from cane, s = theoretical sucrose in a given weight of juice, and b = brix or soluble solids (sucrose and non-sucrose solids) in a given weight of juice.

From this relationship the pounds of recoverable sugar in a given weight of juice is obtained.

A second factor considered under boiling house operation is how nearly actual recoveries approach a theoretical yield. The relation in percent between the actual and theoretical recovery is termed the boiling house efficiency number (BHE). The theoretical recovery is based on another modification of Winter's formula, $100 [1.4 - (40/P)]$, where P is the purity of the raw juice (17). Actual recovery is dependent upon the purity of the sugar produced (11, 17). Since the formula is based on a final molasses purity of 28.57, the production of low purity sugar will automatically raise the retention of sugar in molasses. As a correction to an error in the original method, the sucrose recovery is recalculated to a sugar of 100 pol before dividing it by the theoretical recovery to obtain a proper BHE number. The efficiency number is valuable in estimating sugar yields since it accounts for losses in the boiling house operation as compared with a factory operating under the assumed conditions of Winter's formula. If the purity of the final molasses in a factory is less than 28.57, the BHE may exceed 100 (17).

Arceneaux (4, 9) assumed a BHE number of 100 for all estimated yield calculations, which arbitrarily sets the purity of the final molasses at 28.57. The average BHE number for 10 representative mills operating in Louisiana during the 1970-71 grinding season was 96.72. This means that for every 100 lb of total solids in final molasses, by basing theoretical recovery on the basis of a BHE number of 100, there would be a 2.64 lb sucrose overestimation in sugar yield when compared to the actual performance of these 10 mills. The purity of final molasses for these mills was 31.21.

Many of these error sources can be corrected in calculating sugar yields. Arceneaux (2, 3, 4), realizing the need for a method of rapid calculation of theoretical sugar yields, formulated a simplified method in which he attempted to correct the sources of error. This method used brix and sucrose (pol) values from juice obtained from a single crushing. Juice extraction values and other factors employed in this method were based on previous comparative milling tests.

^{1/} In several publications the formula has been incorrectly referred to as the Winter-Carp-Geerligs formula. Douwes-Dekker (11) indicated that Winter's formula gained wider application due to simplicity. Carp had proposed a separate but similar formula at about the same time but it was not widely used. H. C. Prinsen Geerligs contribution was translating the work of Winter and Carp from Dutch to English.

Arceneaux (2) assumed the amount of 96 pol sugar per ton of cane for each 1% of sucrose in normal juice is 20.83 lb sucrose. (Traditionally this weight and those to follow have been carried to 4 decimal places. Experimental accuracy does not warrant the use of more than 2 decimal places.) This amount is based on the following assumptions: 1) none of the sucrose of the normal juice is retained in the final molasses; 2) the sucrose of the normal juice equalled that of the crusher juice so no correction is needed; 3) all of the juice in the cane, and all of the sucrose, could be extracted in milling; and 4) the BHE number is 100%. The computation involved is as follows:

$$V \quad \frac{2000 \text{ lb} \times 1\% \text{ sucrose increment}}{96\% \text{ sucrose}} = 20.83 \text{ lb}$$

Based on the assumption that each 1 lb of non-sucrose solids in the juice will prevent the crystallization of 0.4 lb of sucrose, the number of pounds of 96 pol sugar that will be tied up in an unabailable form in 1 ton of cane by each 1% of non-sucrose solids will be:

$$VI \quad \frac{2000 \text{ lb} \times 1\% \text{ non-sucrose solids} \times 0.4 \text{ lb sucrose}}{96\% \text{ sucrose}} = 8.33 \text{ lb}$$

The number of 1% increments of non-sucrose solids in the normal juice is equal to the number of 1% increments of total solids (brix) minus the number of 1% increments of sucrose. Consequently, if S in equation IV is the number of pounds of 96 pol sugar (S_{96}) recoverable from a ton of cane, the value of 8.33 can be substituted for 0.4. Equation IV can be rewritten in the following form:

$$VII \quad \begin{aligned} S_{96} &= s_n(20.83) - (b_n - s_n)(8.33) \quad \text{or} \\ S_{96} &= s_n(20.83) - b_n(8.33) + s_n(8.33) \end{aligned}$$

and finally to

$$S_{96} = s_n(29.17) - b_n(8.33),$$

where s_n = number of 1% increments of sucrose in normal juice and b_n = number of 1% increments of brix in normal juice.

The values of s_n and b_n in equation VII are not sucrose and brix percent, per se, although they are commonly stated as such. They are absolute values representing numbers of 1% increments of sucrose and brix in the juice, respectively. However, they are derived in a simple and direct manner from the sucrose percent and brix of the juice, i.e., normal juice having 12% sucrose and 16% brix will have s_n and b_n values of 12 and 16, respectively, rather than 0.12 and 0.16.

Brix and sucrose reduction factors are required to convert crusher juice brix and sucrose to normal juice values. The brix reduction factor is a constant of 0.985, whereas the sucrose reduction factor must be computed separately for each variety from results of the complete mill test described previously. The sucrose reduction factor is calculated by steps. First, the total weights of brix and sucrose extracted from the 80 lb sample are determined. In the second step, the normal juice purity is computed as the ratio of the weight of sucrose to weight of brix. The normal juice sucrose is then determined by multiplying the normal juice brix (crusher juice brix $\times$ 0.985) $\times$ the normal juice purity. Finally, the sucrose reduction factor is computed as the ratio between the sucrose in the normal juice to the sucrose in the crusher juice.

Because all the juice contained in the cane cannot be extracted in milling, it is necessary to make adjustments. Normal juice extraction is calculated by first dividing the total weight of brix extracted by the normal juice brix. This is an estimate of the amount of normal juice weight in pounds. By dividing this weight by 80 lb then multiplying by 100, the normal juice extraction percent is obtained.

Further adjustments to the values of 29.17 lb and 8.33 lb are made as follows to provide for differences between varieties:

$$VIII \quad x = (29.17 \text{ lb}) (a) (c),$$

where x = adjusted value for 29.17 lb (lb of sucrose for each 1% increment of sucrose), a = sucrose reduction factor, and c = normal juice extraction

And

$$XI \quad y = (8.33 \text{ lb}) (b) (c),$$

where y = adjusted value for 8.33 lb (lb of sucrose retained in final molasses for each 1% increment in non-sucrose solids), b = brix reduction factor, and c = normal juice extraction.

No adjustment is necessary for BHE since its value is a standard 100% or 1.00.

The values of x and y are now referred to as sucrose and brix factors, respectively.

Arceneaux (2, 6, 8, 16) further simplified equation IV to read:

$$X \quad S_{96} = (s_c x) - (b_c y),$$

where s_c = number of 1% increments of sucrose in the crusher juice, b_c = number of 1% increments of brix in the crusher juice, x = adjusted value for 29.17 lb as obtained in equation VIII, and y = adjusted value for 8.33 lb as obtained in equation IX.

The x and y values used in equation X are adjusted in equations VIII and IX, respectively, to prevent overestimation by the many factors influencing the amount of recoverable sucrose.

The derivation of equation X does not explain how x and y values are obtained for the varieties in the testing programs or how these values are associated with VCF's. The determination of all x and y values and assignment of VCF's are made on the basis of comparative milling tests using the standard variety Co 281. Arceneaux (3, 4, 5) used Co 281 as his standard because it was widely grown commercially in Louisiana and he had results of milling tests spread over 10 years. He found Co 281 to have an average brix reduction factor of 0.985, sucrose reduction factor of 0.970, and normal juice extraction of 76%. Substituting these data into equations VIII and IX gave x and y values of 21.50 lb and 6.24 lb, respectively. These average sucrose and brix factors for Co 281 were adopted as standards and together were assigned a VCF of 1.00.

Arceneaux calculated further sucrose and brix factors for a range of VCF's (.92, .94, .96, .98, 1.02, 1.04, and 1.06) by multiplying the standard sucrose and brix factors for a VCF of 1.00 by each of the additional VCF's. For example, the sucrose and brix factors for a VCF of 1.02 were calculated as follows: $21.50 \times 1.02 = 21.93$ lb and $6.24 \times 1.02 = 6.36$ lb, respectively. Later use of the VCF's at Houma led to an extension of the range to include x and y values for VCF's of 1.08, 1.10, and 1.12.

A VCF is considered fixed for an experimental variety after 9 or 10 comparative mill tests are conducted with the standard variety. This allows for any differences that might occur between crops, years, etc. However, the values of x and y are fixed and do not change.

Davidson (unpublished) illustrated the determination of VCF's at the Houma Station. Results from a complete milling test supply the data required for assigning VCF's. The original standard variety, Co 281, is no longer being grown commercially; however, varieties of known milling qualities, usually CP 44-101 or CP 52-68, are milled as controls at the same time as the test varieties. The relationship between Co 281 and these controls had been established through earlier tests when they were grown under comparable conditions. A sample of data from an actual milling test is shown in Table 1. Intermediate calculations necessary for computing the sucrose reduction factor and normal juice extraction are shown in Table 2.

Table 1. Basic data for assigning varietal correction factors from complete mill tests using 80 pound samples of the varieties CP 44-101 and L 60-1 conducted at the Houma Station^{1/}.

		CP 44-101				L 60-1			
Item		Sample 1	Sample 2			Sample 1	Sample 2		
Crusher juice	Weight	53.75	53.00	::		50.50	50.37		
	Brix	16.35	16.55	::		18.40	18.47		
	Sucrose	13.04	13.73	::		16.22	16.45		
Mixed juice	Weight	23.50	24.37	::		24.75	25.12		
	Brix	7.80	8.00	::		9.25	9.62		
	Sucrose	6.11	6.48	::		7.90	8.03		
Bagasse	Weight	17.75	18.25	::		20.13	20.13		
	% Fiber	48.10	46.80	::		49.80	45.20		

^{1/} Unpublished data compiled by Lester G. Davidson, former Research Agronomist, Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, U.S. Sugarcane Field Station, Houma, Louisiana.

Table 2. Calculations needed for assigning varietal correction factors for 4 samples of 2 varieties of sugarcane grown and milled at the Houma Station.

	CP 44-101		L 60-1	
Item	Sample 1	Sample 2	Sample 1	Sample 2
Normal juice brix <u>1/</u>	16.10	16.30	18.12	18.19
Brix product <u>2/</u>	10.62	10.72	11.58	11.72
Normal juice weight <u>3/</u>	65.97	65.77	63.91	64.43
Normal juice extraction <u>4/</u>	82.46	82.21	79.89	80.54
Sucrose product <u>5/</u>	8.44	8.86	10.15	10.30
Normal juice purity <u>6/</u>	79.51	82.60	87.61	87.91
Normal juice sucrose <u>7/</u>	12.80	13.46	15.87	15.99
Sucrose reduction factor <u>8/</u>	.982	.980	.978	.972

- 1/ Crusher juice brix X .985 (constant brix reduction factor).
- 2/ Crusher juice weight X brix crusher juice + mixed juice weight X brix mixed juice.
- 3/ Brix product ÷ normal juice brix.
- 4/ Normal juice weight ÷ 80 (weight of sample).
- 5/ Normal juice weight X sucrose crusher juice + mixed juice weight X sucrose mixed juice.
- 6/ Sucrose product ÷ brix product.
- 7/ Normal juice purity X normal juice brix
- 8/ Normal juice sucrose ÷ crusher juice sucrose.

Sucrose and brix factors are computed separately by substituting the necessary data into equations VIII and IX, i.e., for sample 1 of CP 44-101,

$$\begin{aligned}
 x &= (29.17 \text{ lb}) (a) (c) \\
 &= (29.17 \text{ lb}) (0.982) (0.8246) \\
 &= 23.62 \text{ lb}
 \end{aligned}$$

and

$$\begin{aligned}
 y &= (8.33 \text{ lb}) (b) (c) \\
 &= (8.33 \text{ lb}) (0.985) (0.8246) \\
 &= 6.77 \text{ lb}
 \end{aligned}$$

Then by substituting these x and y values into equation X, the expected yield of 96 pol sugar per ton of cane may be calculated as follows:

$$\begin{aligned}
 S_{96} &= (s_c x) - (b_c x) \\
 &= (13.04) (23.62) - (16.35) (6.77) \\
 &= 197.3 \text{ lb}
 \end{aligned}$$

The 3 other expected yields (sugar/ton "a") shown in Table 3 are calculated in the same manner. The expected yields (sugar/ton "b") are calculated yields based on sucrose and brix factors adjusted to a VCF of 1.00. CP 44-101, when comparatively milled with Co 281, had an assigned VCF of 1.02. The 2 sucrose and brix factors found with the 2 samples of CP 44-101 in this test are averaged, then divided by 1.02, resulting in a sucrose and brix factor comparable to a VCF of 1.00 and Co 281. Using these factors, sugar per ton "b" is calculated for both samples of CP 44-101 and L 60-1.

Table 3. Assignment of varietal correction factors for the varieties CP 44-101 and L 60-1 from the relationship between the estimated yields of sugar per ton of cane calculated using amended sucrose and brix factors determined through complete milling tests and yields based on sucrose and brix factors adjusted to a varietal correction factor of 1.00.

Item	CP 44-101		L 60-1	
	Sample 1	Sample 2	Sample 1	Sample 2
Sugar/ton "a" <u>1/</u>	197.31	210.95	248.97	253.50
Sugar/ton "b" <u>2/</u>	191.90	206.44	251.47	256.30
Varietal correction factor a/b <u>3/</u>	1.028	1.022	0.990	0.989

1/ Calculated using amended sucrose and brix factors determined through complete milling tests.

2/ Calculated using sucrose and brix factors adjusted to a VCF of 1.00 keeping sucrose and brix percents same as in sugar per ton "a" calculations.

3/ Obtained by dividing sugar/ton "a" by sugar per ton "b".

The VCF for each sample is calculated from the yield of sugar per ton "a" divided by the yield of sugar per ton "b".

The VCF's assigned to L 60-1 in this test are averaged with the values from any previous test(s). Once 9 or 10 tests are conducted with the new variety the VCF is considered fixed and no further tests are conducted under normal circumstances. After a VCF is assigned to a variety, to calculate the estimated yield of 96 pol sugar per ton of cane from a field sample of cane, the assigned VCF is used to select corresponding sucrose and brix factors. These factors, along with the crusher juice analyses for brix and sucrose, are substituted into equation X resulting in a reliable estimate of sugar yield per ton of cane for that variety.

Arceneaux (4) found that Co 281, with an assigned VCF of 1.00, had average sucrose and brix factors of 21.50 and 6.24 lb, respectively. For convenience, a table has been prepared showing the sucrose and brix factors corresponding to the VCF's most commonly used at the Houma Station. A reproduction of this table is shown in Table 4.

Table 4. Sucrose (x) and brix (y) factors for calculating yield of 96 pol sugar per ton of cane corresponding to assigned correction factors from crusher juice analysis.

Varietal Correction Factor	Sucrose Factor	Brix Factor
.92	19.78	5.74
.94	20.21	5.86
.96	20.64	5.99
.98	21.07	6.11
1.00	21.50	6.24
1.02	21.93	6.36
1.04	22.36	6.49
1.06	22.79	6.61
1.08	23.22	6.74
1.10	23.65	6.86
1.12	24.08	6.99

A variety with a VCF of 1.02 may be interpreted to yield 2% more recoverable sugar per ton of cane than a variety with a VCF of 1.00. Accordingly, a variety with a VCF of 0.98 is expected to yield 2% less. In each of the above cases the quality of the crusher juice is constant.

By comparison, from the results of 121 mill tests in 1970 conducted at Houma, estimated yields exceeded actual yields taken from the Table of Commercially Recoverable Sugar (1) for the same normal juice sucrose values in 119 of these tests. From the results of these comparisons, it appears that estimated yields are still too high.

Normal juice values reported from the Houma Station consistently exceed values reported by commercial mills for the same varieties. This would indicate that normal juice values reported for all

varieties is high. The differences in normal juice quality can be partially explained by the fact that at commercial mills the sample mill juice brix is first factored by a dilution compensation factor (factor used to compensate for differences in the juice quality that exist between the sample mill and the crusher). This new value for crusher juice brix is then factored by the dry milling factor (equivalent to the brix reduction factor) to convert crusher juice brix to normal juice brix.

Experimental mill test samples are hand cleaned with little difference between sample mill juice and crusher juice quality. However, samples from field tests are not hand cleaned and may contain 20 - 40% trash during periods of inclement weather. Under such conditions at a commercial factory it might become necessary to factor its sample mill juice brix with a dilution compensation factor of approximately 0.85 to obtain actual crusher juice brix. Investigations are under study at Houma which should indicate if a dilution compensation factor is required for factoring sample mill juice to true crusher juice in laboratory mill studies.

A possible source of error in analyzing cane juice for sucrose content, especially in experimental varieties where actual recoveries of sugar have not been made by a commercial factory, is false pol (impurities in the juice that affect the optical rotation of sucrose, either adding to or subtracting from). Irvine (15) has shown that the D/L ratio (ratio of dextrose to levulose, two monosaccharides found in cane juice) differ between commercial varieties grown in Louisiana which could have an effect on the expression of actual sucrose in a sample of juice. False pol, if found to be significant between experimental varieties, could cause serious error when reporting juice quality. This, in turn, would cause error in sugar yield calculations. Until more conclusive data are presented, no corrections for false pol are advocated.

Several other aspects of the sugar yield formula are under study. These include normal juice extraction figures obtained from experimental milling results, the fixed relationship of sucrose retained to non-sucrose solids in Winter's formula, and the BHE number which is based also on Winter's formula.

Arceneaux (9) realized that differences did occur in normal juice extraction between his mill equipment and commercial mill tandems, but he felt these differences would not obscure differences in milling quality between varieties. Cane ground in mill tests is free of trash; cane ground by commercial mills may contain as much as 20 - 40% trash. Trash is known to lower extraction. Legendre (unpublished) conducted experiments at Houma with varying levels and composition of trash to examine the effect of trash on extraction in mill tests. Thirty percent trash (green tops and leaves) reduced normal juice extraction by more than 35%. Dry leaves reduced extraction more than did green tops and leaves. To prevent more complex errors by incorporating trash into mill test samples, it is recommended that only clean cane be used.

The relationship of sucrose to non-sucrose in final molasses is based on a molasses purity of 28.57 in Winter's formula. The average molasses purity of 37 commercial factories in Louisiana during the 1970-71 grinding season was 31.47 percent. This would mean that indicated recoveries were higher than actual recoveries providing that the quality of the raw juice was constant. The purity described by Winter was observed for mills operating in Java. Due to the immaturity of the sugarcane being ground in Louisiana, the purity of final molasses for most commercial factories exceeds 30%. It may become necessary to adjust this value for Louisiana conditions.

The BHE number is also dependent upon the fixed relationship of Winter's formula and molasses purity of 28.57. Since the purity of molasses of most commercial factories in Louisiana exceeds this value, the BHE number of 100 is exaggerated. A BHE number of 100 neither adds to nor subtracts from the estimation of sugar yields and can be eliminated from consideration when adjusting the values of x and y in equations VIII and IX. There has been little proven relationship found between BHE numbers and varieties. However, a variety with a low purity normal juice might be expected to lower the BHE number in the factory.

The procedure for determining VCF's could be simplified by eliminating the requirement for a brix reduction factor and BHE number in the calculation of adjusted sucrose and brix factors. Arceneaux (4) indicated that a deviation in the value of the brix reduction factor would be compensated for by reciprocal differences in computed values of the sucrose reduction factor and normal juice extraction. He further stated that measurements of brix reduction factors are of no fundamental importance in experimental milling tests and that final extraction results could be expressed in terms of crusher juice brix.

A composite formula for estimating the yield of 96 pol sugar per ton of cane after eliminating the effects of the brix reduction factor and BHE number would appear as:

$$XI \quad S_{96} = (s_c) [(x) (a) (c)] - (b_c) [(y) (c)]$$

where, S_{96} = number of lb of 96 pol sugar recoverable from a ton of cane, s_c = number of 1% increments of sucrose in the crusher juice, b_c = number of 1% increments of brix in the crusher juice, x = calculated factor of 29.17 lb (equation VII), y = calculated factor of 8.33 lb (equation VII), a = sucrose reduction factor, and c = normal juice extraction.

This formula allows for determination of the number of pounds of 96 pol sugar per ton of cane for the large number of samples associated with field trials. The values of s_c and b_c represent sucrose and brix content of crusher or primary juice. The formula has built in features which factor or make adjustments to meet prevailing conditions, i.e., retention of sucrose by non-sucrose solids, sucrose reduction factor, and normal juice extraction, which makes it directly applicable to unreduced values of brix and sucrose (pol).

No correction is currently made for errors due to overestimating normal juice extraction and normal juice sucrose or errors due to false pol or too high molasses retention. Research designed to produce correction factors for these errors is underway.

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CANE GRINDING AND THE CHANGING TIMES IN THE EVERGLADES

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ABSTRACT

The sugarcane industry in the Everglades, as we know it today, started with The Southern Sugar Co., who built the Clewiston mill in 1927-28, but went bankrupt in 1929 as a result of the depression. The United States Sugar Corp. acquired The Southern Sugar Co. holdings, and in 1930-31, completed their first crop; they have been pioneers and leaders in the sugar business ever since. In the beginning, a large amount of the US Sugar Corp. acreage, which is near Lake Okeechobee on warm land, was undeveloped. There was very little drainage and few roads. A complex system of drainage canals was dug, and mainly through the use of Caterpillar tractors, the land was cleared and developed. Railroad tracks had been laid by The Southern Sugar Co., and steam locomotives were used to haul the cane to the factory. These steam locomotives were eventually replaced by diesel locomotives. At that time, there were only a few varieties of cane, but through the years, research has produced "miracle" varieties too numerous to mention, the most outstanding of which is CL 41-223. As the land and the cane varieties were improved, so was the actual milling equipment. For example, the old Corliss engines that were originally used to drive the mills have long since been superseded by modern steam turbines. The purpose of this paper is to present a brief history of the sugar industry in the Everglades.

HISTORY

The sugarcane industry in the Everglades, as we know it today, began when The Southern Sugar Co. built the Clewiston sugar house in 1927-28. At that time, their holdings included a railroad system, a large amount of acreage, and field and other equipment, as well as the mill itself, which it operated during the 1928-29 and 1929-30 crops.

In 1929, the company began experiencing financial difficulties, and in 1930, entered into a period of receivership. The 1930-31 crop was completed during this period through the efforts of the receivership management. The US Sugar Corp. was organized on April 28, 1931, and participated in these receivership operations. The writer was employed at the Clewiston sugar house at this time.

The 1931-32, 1932-33 and 1933-34 crops were processed by US Sugar Corp., and the receivership was terminated in 1934. Operations were then continued by the Corp., which has been a pioneer and a leader in the sugar business ever since.

At first, a considerable amount of US Sugar Corp. acreage, which is warm land near Lake Okeechobee, was undeveloped. There was very little drainage and few roads in the fields and around the towns in the area. To improve this situation, a complex system of drainage canals was dug, and mainly through the use of Caterpillar tractors, the land was cleared and developed. The field roads were nothing but packed dirt, though, and the marl and sand roads through the towns and to the sugar house were only a little better.

In the fields, the sugarcane was cut, stripped, and loaded by hand and hauled to railroad cane hoists by Caterpillar tractors pulling Athey wagons. Both the tractors and wagons had cleat tracks, and, consequently, were not very fast.

The cane was then transferred to railroad cane cars and hauled to the mill by steam locomotives. These locomotives were fired at first by wood, later by coal, and still later by oil. Today, rubber tired tractors and wagons and diesel-electric locomotives are used.

When the train reached the mill, each car was weighed and pulled by steam winch to the cane dump turntable. In those days, it required 19 men per shift to operate the cane dump. They used poles 15-ft long with hooks on one end to rake excess cane off the top of each car and to clean the cars. Two men on each side of a cane-car compartment door swung it open using door hooks, which were poles 8-ft long with a hook on one end and an eye or handle on the other. Occasionally, it took as long as 1-1/2 hr to unload a particularly bad car.

The long cane, especially a variety called Crystalina, which would sometimes be as much as 12-ft long, was the most difficult to process. Emptying it out of the cars onto no. 1 conveyor presented problems enough, but even worse was when it would sometimes wedge in no. 2 conveyor and cause a jam up to 15-ft high. We would put a plank down in the dump pit on top of the no. 2 conveyor behind the cane to make it lay down and another to make it move. Then, 2 or 3 men usually had to hold onto ropes

for support and get out on top of the cane and jump on it to help get it started moving. When it reached the kicker, this long cane usually choked it and had to be dug out. The situation was often the same when it got to the knife set, and at times, it would not come through the chute entrance to the mill and had to be dug out there, also. Originally, the cane conveyor had wooden slats, and the one cane knife set had blades shaped like Bowie knives with notches in them.

With this type of cane, we counted ourselves lucky if it went through the mill itself without a choke or two more. The mill foreman and the no. 1 engine operator had to know every cane variety by sight or smell in order to set his engine speed and hydraulic pressure to the crusher to feed a blanket of cane into the mill that would allow the best extraction of juice and maintain a satisfactory load on the other engines.

Besides Crystalina, some of those earlier cane varieties were POJ 2714, POJ 2725, Badilla, CP 27-139, Co 281, and F 30-35. Later, F 31-436, which was a good grinding, low fiber cane, was developed. Many of these varieties often became diseased, though, and as a result, our research people were, and still are, kept busy coming up with new ones. They do this, of course, not only to combat disease, but also to obtain, among other things, higher sucrose yields, and early as well as late maturing varieties. The miracle cane, CL 41-223, is a product of the research done by our people.

The crusher was powered at first by a Hamilton corliss engine, and following the crusher was an extremely temperamental Ewart carrier, which at times almost drove us crazy. Mills no. 1, 2 and 3 were pulled by a Hamilton corliss engine also, and Mills no. 4, 5 and 6, by a Fulton corliss engine, one of the largest of its kind in the world. We also used leaf type filter presses, an accumulator type hydraulic system, and Manzel force feed lubricators to oil the mill journals. However, in 1939, H. J. B. Scharnberg, superintendent of the mill at that time, had the Ewart carrier replaced with the first Farrel-Scharnberg mill, which was driven by an electric motor. This then gave us 7 mills, the last 6 still being driven by Hamilton and Fulton corliss engines.

This set-up was eventually changed when, during the 1958 and 1959 repair seasons, under the direction of Harry T. Vaughn, John B. Boy and C. A. Martinez, the tandem was turbinized.

During those earlier years, some of the methods we used to keep things running were certainly unconventional by today's standards. For instance, to use in case of hot bearings, of which we had plenty, we mixed our own concoction or dope, which consisted mostly of acorn oil, Kellogg's steam oil and white lead. We applied this dope to the bearings with a swab stick, and sometimes when it did not stick satisfactorily, we used Octagon soap to make it adhere better. For years, we did not have lateral, or chevron, grooves on the mill rolls, and another example of some of the measures we took to do a better job of grinding cane was the practice of chopping the rolls with axes to make them rough.

There were times, of course, when in spite of all our efforts to keep going, we had to shut down. One of those times was when the top rool shell on no. 7 mill came loose, but the shaft continued to turn. Another time, the no. 6 mill coupling broke and just fell to the floor. And still another time, the no. 2 engine blew the whole cylinder head out. In 11 hrs, we were grinding again, and 2 weeks later, after patching it up, we were using the same engine. For the next crop, though, we installed a new engine.

We worked 12-hr shifts, 7 days a week. Six of those days, we ground cane, and on the seventh, we shut down for cleaning and repairs. When World War II took most of the young men, we hired older men, women and high school students in order to keep operating, but for 2 crops, we could only grind from 7-9 cars an hour due to the labor shortage. Finally, we were able to obtain labor from Jamaica, Barbados and other islands, and the practice has continued.

Before we progressed to the sugar handling systems that we have now, the end result of all the work in the fields and the mill, the sugar, was put into bags, which were sewn shut by hand and, then, taken to a conveyor on small 2-wheeled hand trucks. At the end of the conveyor, a man would catch a 327 lb sack on his back and carry it to a railroad car. The sacks were stacked 4-deep in the cars, and the workers were, at one time during the lean years, paid 11 cents an hour for doing this 12 hrs a day.

The Clewiston sugar house had been in operation for 32 crops when, in 1962, 7 new mills were completed around Lake Okeechobee. One of the 7 was US Sugar Corp's Bryant Sugar House. A. R. Mayo, who is now Vice President over both our mills, was named as the 1st superintendent of the Bryant sugar house. During the erection of the mill and to begin operations, the Corp. transferred a number of us from Clewiston to Bryant. Starting off with a new crew of men and a completely new mill with much automation was certainly an experience. That 1st year, the Bryant mill averaged grinding 5,640.88 tons of cane per day. We used the scale house, topping crane and steam winch to pull the cars onto the cane dump until 1966, when our people designed, built and installed an automated cane dump. It proved to be so efficient that one was later installed at the Clewiston Sugar House, also. Other innovations at Clewiston included increasing the length and diameter of the mill rolls. Many modifications and additions, of course, have been made at Bryant sugar house in the last 10 years, and we averaged for the 1971-72 crop, 9,931.15 tons of cane per day.

None of the changes and improvements that have been made in the operations of US Sugar Corp. mills would have been possible without good leadership. From the administration of Clarence R. Bitting, our first president, right on through those of Charles E. Wetherald and Harry T. Vaughn

to the present one of John B. Boy, and in key personnel too numerous to mention, we have been fortunate in having excellent management.

Much credit is due, too, to the men working behind the scenes in all the various departments. The skills involved in adjusting mill settings, in regulating the speed and thickness of the cane blanket feeding into the mill, and in using the correct amount of maceration, as well as in many other processes, are vital in order to obtain the best results possible with a minimum amount of lost time.

In concluding this short history of today's sugar industry in the Everglades, it must be said that the teamwork in our organization certainly has produced impressive results over the years, as can be seen in the following table:

Clewiston sugar house

1930-31 crop, 137 days

Tons of cane ground for crop	342,224.15
Tons of cane ground per day	2,497.98
Tons of cane ground per hour	136.15

1971-72 crop, 112 days

Tons of cane ground for crop	1,021,040.61
Tons of cane ground per day	9,192.53
Tons of cane ground per hour	409.00

Bryant sugar house

1962-63 crop, 148 days

Tons of cane ground for crop	834,850.31
Tons of cane ground per day	5,640.88
Tons of cane ground per hour	256.51

1971-72 crop, 112 days

Tons of cane ground for crop	1,103,846.89
Tons of cane ground per day	9,931.15
Tons of cane ground per hour	431.25

THE FOURTH PHASE WHICH AFFECTED THE LONG TERM SUCCESSFUL FOUNDING OF THE FLORIDA CANE SUGAR INDUSTRY

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ABSTRACT

The central object of this paper is to make available the commercial yield performance of the variety Cl 41-223 for 21 consecutive crop seasons and compare these with those of the 2 major varieties, F 31-436 and F 31-962, which preceded it and which were the most important of the 1st 3 economically successful varieties which formed the basis of the Florida cane sugar industry. It was found that Cl 41-223 averaged increased yields of 96° sugar per acre over F 31-436 and F 31-962 by 28% and 84%, respectively. Also, the commercial results of Cl 41-223 were compared with those of the original group of exotic varieties during the earliest 5-year period from 1931-1936, when sugarcane as a commercially profitable crop in Florida was highly debatable. The increased yield of 96° sugar per acre averaged 92% above that of the early period cited. References to the origin, descriptive features, cold and disease resistance plus other characteristics of Cl 41-223 are given. A brief resume is also given of the preliminary replicated field tests of this cane along with the best available selected varieties on both organic and sandy soils in the Everglades prior to release in late 1949 for commercial use. The performance of this cane variety during 21 crops from 1950-1971 involved the milling of 15,576,250 tons of cane and the recovery of more than 1,632,000 tons of 96° sugar therefrom. Two serious crises arose during phase 4. The 1st involved the epidemic spread of a newly recognized disease called ratoon stunting in the early 1950's which greatly reduced the yield of the major variety F 31-962 and was associated with a new and virulent strain of red rot disease causing the rapid decline of the other major variety F 31-436. The 2nd crisis occurred in 1960 when a large group of potential new cane farmers threatened to import large supplies of seedcane from Louisiana and foreign countries, thus opening wide the door to many new and very destructive diseases and pests unknown in Florida. Details are presented showing the leading part the author took in solving both of these major problems effectively.

INTRODUCTION

This is a continuation of the brief review by the author (7) of the 1st 3 developmental phases which affected the successful founding of the Florida cane sugar industry. All the information given in this paper is based on the records of US Sugar Corp., the largest and first successful sugarcane grower in Florida. During the last 10 years of phase 3, the acreage of cultivars F 31-436 and F 31-962 were expanded sufficiently to prove positively that sugarcane could be grown to produce sugar economically in Florida. It was realized that further improvements were needed in order to justify additional capital expenditure or expansion of acreage and increase in milling and sugar processing capacity.

METHODS USED FOR DETERMINING YIELD PERFORMANCE OF CULTIVATED VARIETIES

The agricultural department of the Corporation prepares annually a summary for each commercial variety showing the acreage and cane tonnage milled, the average yields of cane per acre, the % yield of 96° sugar, and the sugar per acre. The % yield of 96° sugar is obtained by recording the chemical analysis of each single or multiple carload composite crusher juice sample at the sugarhouse from each field. Thus, the total sugar produced from all the fields of each variety divided by the total acreage of the variety allows for the determination of the simple cumulative average yield figures in the tables given in this article.

THE FOURTH DEVELOPMENTAL PHASE

Since the parental background of the new leading sugar cane clone Cl 41-223, its typical field growth characteristics and its outstanding commercial performance in the year 1963 have already been reviewed in some detail by the author (4), mention will first be made of some of the previously unpublished facts regarding the creation and 1st 2 selections by the author. The parents, F 31-436 (female) and F 31-452 (male) were both bred and selected by the author, the former a major commercial variety and the latter a sib variety, previously showing cold resistance. The cross had long been planned but was never accomplished until the breeding season of 1940-1941, when an estimated 6,450 seedlings resulted therefrom in February - March 1941. All the progeny were screened when 6 weeks old for vigor and disease resistance. To do this, all the plants were sprayed with a mixture

of equal parts of aqueous suspension of young vigorous cultures of the causal fungi of eye spot and brown stripe diseases. Within 10 days, the disease susceptible plants could be readily screened from the healthy ones. Then 789 of the most vigorous, healthy ones were transplanted in 4" paper pots and 2873 of the fairly vigorous and healthy ones were transplanted 2" x 2" apart in flats. The 3,662 transplanted selections were grown outdoors for hardening during a period of 3 - 4 weeks before they were established in the field in rows 8 ft apart and 4 ft apart in the row between June 12 and 26, 1941.

The next screening of this seedling group was after the plants were reaching maturity in early December 1941. Several of the most vigorous and healthy stools, including the one eventually numbered Cl 41-223, were tagged with steel stakes. Then, in January 1942 a frost at 32 F occurred and, about a month later, a freeze at 29 F. These cold spells gave me an opportunity to select those which showed little or no apical or lateral bud damage. Several selections were made for this most valuable characteristic and the one eventually designated Cl 41-223 was tops in this group. It was then necessary to harvest and fertilize the seedling block and prepare the stubbled stools for final testing in the late fall and winter of 1942 and early 1943 for °brix of juice and other characters. These tests were jointly performed with L. M. Weetman, newly appointed on February 16, 1942, and members of the sugar chemistry and agronomy departments. Experimental yield data acquired by Weetman and Hundertmark (12) during the late 1946 - 1949 testing period included this variety during 3 crop cycles in a group of the best 25 selected clones on low mineral organic soil several miles distant from the cold-protective influence of Lake Okeechobee. The trial was a randomized block with 4 replications. The leading commercial varieties were included as controls. Tables 1 and 2 summarize the experimental performance of Cl 41-223 and 2 important commercial cultivars. Cl 41-223 proved to be significantly superior to F 31-436 and F 31-962 in both cane tonnage and quality.

Table 1. Summary of 3 yearly crop yields on low mineral organic soil comparing the results of Cl 41-223 with F 31-436 and F 31-962.

Variety	Mean yield							
	96° Sugar							
	% cane							
			Tons cane/acre			Tons 96° sugar		
	Early analysis	Late analysis	46-47	47-48	48-49	46-47	47-48	48-49
Cl 41-223	9.63	11.77	64.42	45.37	30.61	7.82	5.19	3.59
F 31-436	8.96	10.39	58.47	48.31	25.88	6.36	5.02	2.56
F 31-962	9.74	10.85	53.28	37.09	25.24	6.08	4.26	2.45
Sig. diff. (.05)	1.18	0.99	5.97	6.57	3.10	0.61	0.95	0.41

Table 2. Summary of total crop yields for 3 crop years on low mineral organic soil.

Variety	Tons sugar per acre			
			significant	
	Total yield per acre		Over	Over
	Tons cane	Tons 96° sugar	F 31-436	F 31-962
Cl 41-223	140.40	16.60	1.46	2.63
F 31-436	132.66	13.94	-	None
F 31-962	115.61	12.77	-	-
Sig. diff. (.05)	9.41	1.20		

During the years 1946-47 and 1947-48 a similar trial was also conducted on low organic sandy soil by Weetman and Hundertmark (11), using Cl 41-223 and 11 of the best adapted varietal selections. These workers reported that Cl 41-223 was significantly lower in total cane per acre for two crops when compared with the top yielding variety Cl 41-191; but due to its superior yield of 96° sugar per ton of cane, it proved to be insignificantly different in yield of 96° sugar per acre to the latter variety. It was thus established that Cl 41-223 could be used on both high and low mineral organic soils and on the low organic sandy soils.

Throughout the testing period from 1942 to 1949, it was observed frequently that Cl 41-223 was outstanding in resistance to leaf damage by light frosts which destroyed the foliage of F 31-436 and F 31-962 in replicated trials. Furthermore, after the mature standing cane was severely frozen, it deteriorated in sugar content very slowly. These cold resistant attributes were recorded in 1956 and again in 1964 (4).

The remarkable resistance of Cl 41-223 to sucrose deterioration after a freeze was observed on a commercial scale by Doty (9). On February 5, 1958, a temperature of 22 F virtually killed all leaves and stalk buds of all cultivated varieties. In spite of this damage the sugar content of Cl 41-223 continued to increase for 2 weeks before starting to decline slowly. A month after the freeze, the yield % cane of 96° sugar had fallen from 11.45% down to 11.30%, or only 0.15 points, an insignificant decline of 1.3%. On the other hand, F 31-436, which had previously experienced a moderate freeze on January 9-10, 1958, increased in sugar content for 12 days before starting a rapid decline. In fact, after the 2nd freeze of February 5, 1958, the latter cane deteriorated very rapidly with a loss of 17% in 30 days.

NOTES ON THE RED ROT AND STEM ROT DISEASES

It was reported in 1953 (2) that the major variety F 31-436, which was grown for more than 14 years in phase 3, was only noticeably damaged by the *Physalospora* red rot fungus when heavily attacked by the stalk moth borer or when high winds and flooding rains occurred during the susceptible period of vegetative growth. Nevertheless, in comparative tests with the prevalent light and virulent strain of this fungus, F 31-436 was definitely more susceptible to red rot than Cl 41-223, but slightly more resistant to the *Fusarium* stem rot fungus, which often occurred along with the red rot organism. In other words, it was not due to a red rot or stem rot crisis that Cl 41-223 was selected to replace this former cane or the other major variety F 31-962, but rather its much higher yields of sugar per acre and resistance to cold damage plus immunity to infection by all the local strains of mosaic virus under field conditions.

THE REPLACEMENT OF F 31-436 AND F 31-962 WITH Cl 41-223

Tables 3, 4, 5, and 6 summarize the acreages, total and average cane and sugar yields per acre and % yield 96° sugar given by Cl 41-223 and by all varieties, excluding Cl 41-223, as recorded by the US Sugar Corp. administration sugar production program during the 21 crop years commencing with 1950-51. Of the 28,058,553 tons of administration cane milled by the Corp., there were 15,576,250 tons, or 55.5% of Cl 41-223 (Table 3). This review, therefore, ties onto the author's previous publication (6) and permits an evaluation of results from extremely large acreages and cane tonnages milled by the largest cane grower in Florida.

Table 3. Cane tonnages milled of cultivar Cl 41-223, of all administration cane with and without Cl 41-223 and the percentages of the latter cultivar during 21 crop cycles.

Crop year	Cane tonnage milled			
	All administration	All administration	Of Cl 41-223	% Cl 41-223
	cane	cane	alone	of all administration
		less Cl 41-223		cane
1950-51	936,238	921,876	14,362	1.5
1951-52	986,250	944,416	41,834	4.2
1952-53	1,150,511	1,050,227	100,284	8.7
1953-54	1,066,887	865,905	200,982	18.8
1954-55	947,706	700,680	247,026	26.1
1955-56	887,580	600,408	287,172	32.4
1956-57	866,971	439,298	427,673	49.3
1957-58	1,000,995	280,173	720,822	72.0
1958-59	965,361	233,924	731,437	75.8
1959-60	1,250,626	242,304	1,008,322	80.6
1960-61	1,068,072	187,871	880,201	82.4
1961-62	1,197,956	170,787	1,027,169	85.7
1962-63	1,664,746	305,251	1,359,495	81.7
1963-64	1,684,575	335,670	1,348,905	80.1
1964-65	1,941,415	376,450	1,564,965	80.6
1965-66	1,587,837	439,392	1,148,445	72.3
1966-67	1,877,977	826,690	1,051,287	56.0
1967-68	2,064,520	1,107,563	956,957	46.4
1968-69	1,675,323	1,007,890	667,433	39.8
1969-70	1,556,267	744,402	811,865	52.2
1970-71	1,680,740	701,126	979,614	58.3
Total	28,058,553	12,482,303	15,576,250	

Table 4. Summary data of administration cane for 21 crop seasons regarding average % yields of 96° sugar.

Crop year	% yield 96° sugar (average)			
	All cane varieties	Cl 41-223	All cane varieties	% increase or decrease of
	less Cl 41-223	alone	including Cl 41-223	Cl 41-223
1950-51	8.97	10.16	8.99	+ 13.27
1951-52	9.29	10.01	9.32	+ 7.75
1952-53	8.98	10.91	10.02	+ 21.49
1953-54	9.90	10.43	10.00	+ 5.35
1954-55	9.84	10.94	10.12	+ 11.18
1955-56	9.42	10.80	9.87	+ 14.65
1956-67	9.98	11.03	10.50	+ 10.52
1957-58	8.65	10.10	9.69	+ 16.76
1958-59	9.67	10.34	10.18	+ 6.93
1959-60	9.04	9.63	9.52	+ 6.53
1960-61	9.59	10.22	10.11	+ 6.57
1961-62	9.28	10.78	10.56	+ 16.16
1962-63	9.96	10.34	10.15	+ 3.82
1963-64	8.58	10.24	10.12	+ 19.35
1964-65	9.50	9.36	9.39	- 1.47
1965-66	10.26	10.17	10.20	- 0.88
1966-67	10.36	11.03	10.73	+ 6.47
1967-68	10.99	11.38	11.17	+ 3.55
1968-69	10.71	10.78	10.74	+ 0.65
1969-70	10.61	10.73	10.70	+ 1.13
1970-71	11.42	11.66	11.60	+ 2.10
Mean	9.76	10.53	10.18	+ 8.18

Table 5. Acreages and average cane and 96° sugar yields per acre of all administration cane milled during 21 crop seasons.

Crop	Acreage milled of		Average yield of		Average yield	
Season	All cane,		all cane varieties, ^a		of	
	Excluding	Cl 41-223	excluding Cl 41-223		Cl 41-223 alone	
	Cl 41-223		Tons per acre		Tons per acre	
			Cane	Sugar	Cane	Sugar
1950-51	25,558	255	36.07	3.235	56.32	5.722
1951-52	25,429	819	37.12	3.448	51.08	5.113
1952-53	26,037	1,733	40.34	3.621	57.87	6.314
1953-54	24,434	3,798	35.44	3.510	52.92	5.520
1954-55	19,772	4,895	35.44	3.486	50.47	5.521
1955-56	16,505	5,954	36.38	3.428	48.23	5.209
1956-57	10,870	8,534	40.41	4.033	50.11	5.527
1957-58	7,533	13,514	37.19	3.216	53.34	5.387
1958-59	6,010	16,172	38.92	3.765	45.23	4.677
1959-60	6,566	20,794	36.90	3.337	48.49	4.670
1960-61	5,477	21,994	34.30	3.288	40.02	4.090
1961-62	3,812	23,880	44.80	4.156	43.01	4.636
1962-63	6,987	31,169	43.69	4.352	43.62	4.510
1963-64	8,482	34,459	39.57	3.397	39.15	4.009
1964-65	11,003	43,731	34.21	3.250	35.79	3.350
1965-66	12,854	31,499	34.18	3.508	36.46	3.708
1966-67	19,363	25,835	42.69	4.423	40.69	4.488
1967-68	24,797	20,607	44.67	4.910	46.44	5.285
1968-69	26,232	17,114	38.42	4.115	39.00	4.204
1969-70	18,366	18,062	40.74	4.321	44.95	4.823
1970-71	17,999	22,384	38.69	4.419	43.76	5.102

Table 6. Commercial record of total tons 96° sugar produced for each of 21 crop seasons from Cl 41-223, all varieties less Cl 41-223 and all varieties combined (1950-1971).

Crop	Acreage	Tons 96° sugar from		
	milled of	All varieties	All varieties,	Cl 41-223
season	all varieties	combined	less Cl 41-223	alone
1950-51	25,813	84,150	82,691	1,459
1951-52	26,248	91,868	87,680	4,188
1952-53	27,770	115,246	104,304	10,942
1953-54	28,232	106,717	85,752	20,965
1954-55	24,667	95,955	68,930	27,025
1955-56	22,459	87,590	56,576	31,014
1956-57	19,404	91,005	43,838	47,167
1957-58	21,047	97,027	24,227	72,800
1958-59	22,182	98,266	22,630	75,636
1959-60	27,360	119,016	21,908	97,108
1960-61	27,471	107,961	18,006	89,955
1961-62	27,692	126,552	15,844	110,708
1962-63	38,156	169,031	28,414	140,617
1963-64	42,941	170,476	28,815	141,661
1964-65	54,734	182,264	35,765	146,499
1965-66	44,353	161,888	45,090	116,798
1966-67	45,198	201,583	85,636	115,947
1967-68	45,404	230,652	121,744	108,908
1968-69	43,346	179,886	107,939	71,947
1969-70	36,428	166,476	79,363	87,113
1970-71	40,383	193,741	79,538	114,203
Total	691,288	2,877,350	1,244,690	1,632,660

SOME COMPARATIVE RESULTS OF CULTIVAR C1 41-223
AND THOSE OF MAJOR CULTIVARS IN PHASE 3

As reported previously (6), the cultivars F 31-436 and F 31-962 were of major importance during phase 3 of the Florida sugar industry development. Table 7 summarizes the mean yields of these cultivars during the 13 and 14 crop cycles, respectively, up to 1950-51 in regard to % yield 96° sugar, tons of cane and 96° sugar per acre. In this summary is also given the mean yields of C1 41-223 for the same factors during the 21 crop cycles from 1950-51 - 1970-71. It is seen that C1 41-223 averaged 14.08% increase of 96° sugar % cane over F 31-436 and 20.34% increase over F 31-962. In tons of cane and 96° sugar per acre C1 41-223 averaged 5.08 and 17.28% increases, respectively, over F 31-436. Similarly, C1 41-223 averaged 41.87 and 68.92% increases, respectively, over F 31-962. It is obvious from the above results during phase 4 that the improvements in cane quality and in tons of cane and 96° sugar per acre are great when compared with the former 2 outstanding cultivars F 31-436 and F 31-962, which served well during the early successful founding period of the Florida sugar industry.

Table 7. Mean yields of C1 41-223 during 21 crop cycles in phase 4 compared with those of major cultivars F 31-436 and F 31-962 during phase 3.

Factor studied	F 31-436	F 31-962	C1 41-223	Percent increase	
	period	period	period	of C1 41-223	
	1938-39 to 1950-51	1937-38 to 1950-51	1950-51 to 1970-71	over F 31-436	F 31-962
% yield 96° sugar	9.23	8.75	10.53	14.08	20.34
Tons cane per acre	40.37	29.90	42.42	5.08	41.87
Tons 96° sugar per ac.	3.791	2.632	4.446	17.28	68.92

It is interesting to note also that the average yields of cane and 96° sugar per acre for all cane varieties milled, excluding C1 41-223, during the 21 year cropping period were 38.52 and 3.841 tons, respectively. Since the averages for C1 41-223 during this same long cropping period were 42.42 and 4.446 tons per acre, respectively, it is obvious that C1 41-223 averaged 10.12% more cane per acre and 15.75% more 96° sugar per acre than all the other cane produced and milled by the Corp.

As a matter of historical interest, let us also compare the results given by C1 41-223 with those of the 1st 5 crop seasons between 1931 and 1936 when US Sugar Corp. first entered the cane sugar business in Florida and was forced to cultivate several exotic cane varieties, such as the group from Java, POJ 2725, POJ 2714, POJ 36, POJ 36M and POJ 213, 2 from India, Co 281 and Co 290, and 1 from the West Indies, SC 12/4. Seedcane of all the exotic varieties was originally obtained from the USDA at Canal Point, Florida.

The data for the exotic group, compiled by the author and now in press (6), are presented in Table 8. C1 41-223 averaged a 26.3% increase in % yield of 96° sugar, 40.9% increase in tons of cane per acre and 76.0% increase in tons 96° sugar per acre over the corresponding yields given by the exotic group.

Table 8. Percent increase given by cultivar C1 41-223 during phase 4 over the exotic cultivars of phase 2.

Factor studied	Average of exotic cultivars	Average of C1 41-223	% increase by
	during phase 2, 1931-36	during 1950-71	C1 41-223
% yield 96° sugar	8.34	10.53	26.3
Tons cane/acre	30.1	42.42	40.9
Tons 96° sugar/acre	2.526	4.446	76.0

The results of C1 41-223 are indeed good, not only when compared with those of the old original exotic cultivars but also with the major cultivars during phase 3, and prove conclusively how well C1 41-223 has helped to establish the Florida sugar industry on a secure and profitable basis.

NOTES ON 2 MAJOR CRISES WHICH OCCURRED
DURING PHASE 4

The 1st crisis occurred during the early transition period from 1950 onwards when the major varieties F 31-436 and F 31-962 were starting to be replaced by the much higher yielding Cl 41-223. The presence of a new disease, ratoon stunting, was reported in the Everglades region in 1950. This disease was first reported in Australia by Steindl (10). An immediate survey was undertaken to determine how widespread the disease was and then arrangements were made to conduct many comparative field and laboratory tests to determine the relative resistance and susceptibility of all major commercial varieties. Also, a concerted effort was made to find an economic method of controlling this disease. The results of many of these studies have already been reported by the author, but special attention is called to 2 papers which embody pertinent information necessary to the proper solution of this problem. The 1st paper (3) gives for the first time in Florida a hot air treatment of sugarcane seedpiece stalks which proved to be 100% effective in eliminating the causal factor of RSD. This procedure, as noted in the 2nd paper (5), has been used for more than 15 years by this Corp. with 100% success and consists of bringing the temperature of the stalks and air in an electrically heated chamber up to 50 C and then thermostatically controlling the temperature at this constant level for 24 hrs before planting the seedpieces. By planting propagation blocks of seedpieces in well protected areas as sources of commercial planting stock plus the use of sterile cutting knives, the Corp. has been able to maintain the productive capacity of this and other commercial varieties very successfully.

The 2nd crisis was brought to light in September 1960 when E. H. Todd, Plant Pathologist at the US Sugarcane Field Station at Canal Point, Florida, wrote to the author about the pressure being brought by a large group of potential new sugarcane growers to import large supplies of seedcane from Puerto Rico and Louisiana to plant many thousands of acres. The sudden market for seedcane developed as a result of a decision by the US to cut off the entire Cuban sugar quota. Dr. Todd discussed the situation with me and advised that he had already contacted the District Supervisor of Plant Pest Control of the USDA at Coral Gables, Florida, and Dewey Stewart, Acting Chief, Tobacco and Sugar Crops Research Branch, USDA and suggested that the Florida sugarcane industry notify the State Plant Board of Florida so that proper action could be taken by State officials. As a professional plant pathologist who had spent the previous 31 years breeding and supervising the development of the outstanding disease resistant varieties which had become the basis of our successful sugar industry during phases 3 and 4, the author fully realized the inadequacy of the then existing plant quarantine law, P.Q. 57-10, as revised on August 6, 1959. I immediately wrote on September 19, 1960, to the Chief of the Florida State Plant Board and to W. T. Forsee, Jr., Chemist in Charge of the University of Florida Everglades Experiment Station, and pleaded for prompt action to prevent the importation of seedcane into Florida, citing the great dangers such importations would entail.

After contacting W. G. Cowperthwaite, Plant Commissioner of the Florida State Plant Board at Gainesville, the author wrote him a letter explaining the sugar industry crisis in great detail and attaching a draft of pertinent information listing some 20 sugarcane diseases officially recorded from states close to Florida and which had not yet been reported or known to occur in Florida. Also a list of 7 insect pests of sugarcane known in Louisiana but not in Florida were also given in the draft, which was to form the basis of his urgent action to obtain legal plant quarantine protection for the Florida sugar industry.

As a result of the prompt actions taken by the author and the various officials cited above, an emergency quarantine on seedcane imports into Florida was declared on October 5, 1960, by Florida Governor LeRoy Collins and on November 18, 1960, the Florida State Plant Board adopted the rules and regulations made by the Board pursuant to the Florida Plant Act of 1927 covering diseases of sugarcane in Special Bulletin No. 32. This new law fortunately prohibits the importation of all the cultivated and wild grasses which are known to carry cane diseases, a request which the author had specifically made in his original petition. It is interesting to note that prior to the above actions taken to protect our cane sugar industry, and according to a letter dated September 26, 1960, by W. G. Cowperthwaite, Florida Plant Commissioner, under rule 8 of the Florida Plant Act as of that date, the State of Florida itself had no quarantine on sugarcane. Therefore, I feel very gratified for having had the opportunity to take a leading part in building the existing legal barrier against foreign diseases and pests which conceivably could threaten the economic survival of our cane sugar industry. This barrier also reinforces our federal quarantine laws against the entry of plant pests and diseases.

During the past 10 years, there has been considerable emphasis on very early canes adapted to the colder lands, including Cl 54-336, Cl 54-278, Cl 54-312, Cl 54-405, Cl 54-241, Cl 54-1910, Cl 59-1332, Cl 59-994 and others, but the results of these and other important matters will have to be portrayed by others under phase 5.

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TESTING OF SUGARCANE VARIETIES FOR MILLING QUALITY

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ABSTRACT

The method of calculating the varietal correction factor (VCF) and the simplification of the Winter-Carp formula for determining theoretical yields of sugar per ton of cane, as described by Arceneaux, are reviewed. A modification of the equation for calculating VCF is offered. The product of normal juice extraction and sucrose reduction factor is obtained for each variety. The product for a test variety divided by the product for the check variety is the VCF.

Analyses of variance of data involving determination of normal juice extraction, sucrose reduction factor, VCF, fiber content and percent sucrose (pol) in crusher juice are presented. There are 5 varieties in 8 tests over 3 harvest seasons in the study. A comparison is made of the reliability of each parameter as a criterion in evaluating sugarcane varieties in the early stages of testing.

Accurate testing of sugarcane for recoverable sugar involves several considerations. While a knowledge of field experimental design is essential, it is also necessary to have some knowledge of factory milling and sugar processing. The amount of sucrose in cane varies with variety, age of the crop, environmental conditions under which it is grown, and possibly other factors. The amount of sugar that can be recovered from sugarcane depends on the amount of juice that can be extracted and the quality of the juice. The quantity of juice that can be extracted from cane depends on the fiber content, the characteristics of the fiber, and the efficiency of the milling equipment. Extraneous matter, such as cane foliage, not only adds to the weight of material that must be transported to the factory but also reduces the total amount of juice that can be extracted and affects boiling house performance. In evaluating new varieties, it is desirable to determine relative yields rather than absolute yields. Variations in fiber content, juice extraction, juice quality and total cane yields are frequently greater between samples or plots of the same variety than they are between different varieties. Oftentimes age of the crop, environmental factors, and especially soil types, have a greater influence on juice quality and quantity than do the differences due to varieties.

In previous reports (1, 2, 3) it was shown that the relative values for juice extraction, sucrose reduction factors and varietal correction factors (VCF) are relatively stable under wide ranges of growing conditions. Although the system used in determining the VCF has been reported by Arceneaux (1), it is of interest to briefly describe this method and show the derivation of conventional x and y factors in use at the Canal Point Station in recent years.

Arceneaux (1) simplified the empirical formula (Winter-Carp) for calculating theoretical sugar yields in cane by using x and y factors derived as follows: According to the formula it is assumed that each lb of non-sucrose solids in the juice will retain 0.4 lb of sucrose. In its simplest form, therefore, the formula could be expressed as follows:

$$s = (e) - [(0.4) (f - e)]$$

in which s = lb of recoverable sugar in the juice, e = lb of sucrose in the juice, f = lb of total solids (brix) in the juice. By use of this algebraic expression it can be shown that 1 ton of cane with 1% sucrose in the juice subject to the following milling factors - reduction factor = 1.00, boiling house efficiency number = 100%, and juice extraction = 100% - will yield 20.833 lb of 96° sugar. According to the Winter-Carp formula, 1% of non-sucrose soluble solids in the juice from 1 ton of cane will retain in solution 8.333 lb of 96° sugar. Substituting these values in equation 1 on the basis of 96° sugar we have the following, in which s' = lb of 96° sugar per ton of cane; s = % sucrose and B = % brix:

$$s' = s(20.83333) - [(B - s) (8.3333)]$$

$$s' = s(20.83333) - [B(8.3333) - s(8.3333)]$$

$$s' = s(20.83333) + [(s(8.3333)) - B(8.3333)]$$

$$s' = s(29.16667) - B(8.3333).$$

The x and y values are based on the following calculation:

$$I \quad Y = Sx - By$$

where: Y = lb 96° sugar per ton of cane, S = sucrose % primary extracted juice, B = brix % primary extracted juice, x = the varietal pol correction factor, and y = the varietal brix correction factor.

Theoretical boiling house recovery or retention is based on the Winter-Carp formula. This formula was developed from the observation that 1 part of non-sucrose solids retains 0.4 parts of sucrose in the final molasses. With this interpretation the formula may be stated as (6):

$$II \quad y' = \frac{s - 0.4(b - s)}{s}$$

where: y' = parts sucrose recovered per part sucrose extracted, s = sucrose % juice, and b = brix % juice.

The loss to molasses may be expressed as:

$$III \quad m = 0.4(b - s)$$

where: m = parts sucrose to molasses per part non-sucrose extracted.

The varietal correction factors x and y under normalized conditions as qualified below are determined as follows:

$$IV \quad x = 2000 \times \frac{NJE}{100} \times SRF \times y' \times \frac{BHE}{100} \times \frac{1}{0.96}$$

where: x = lb 96° sugar per ton of cane per 1% sucrose in primary juice, NJE = normal juice extraction, SRF = sucrose reduction factor: sucrose in normal juice divided by sucrose in primary juice, y' = theoretical retention (equation II), BHE = boiling house efficiency, and 1/0.96 = 1 lb 96° sugar per 1 lb sucrose.

For the conditions of 1.00% sucrose in primary juice, no non-sucrose solids (purity = 100), 100% NJE, 1.00 SRF, and 100% BHE,

$$x = 0.01 \times 2000 \times 1.00 \times 1.00 \times 1.4 \times 1.00 \times 1/0.96 = 29.16667.$$

Also:

$$V \quad y = 2000 \times \frac{NJE}{100} \times BRF \times m \times \frac{BHE}{100} \times \frac{1}{0.96}$$

where: y = lb 96° sugar per ton of cane per 1% brix in primary juice, BRF = brix reduction factor: brix in normal juice divided by brix in primary juice, and m = molasses loss (equation III).

For the conditions of 1.00% brix in primary juice and a brix reduction factor of 1.00,

$$VI \quad y = 0.01 \times 2000 \times 1.00 \times 0.4 \times 1.00 \times 1/0.96 = 8.3333.$$

Substituting in Equation 1, we have

$$Y = S(29.16667) - B(8.3333)$$

Variations in percent juice extraction, boiling house efficiency, and reduction factors from the assumed 1.00 will proportionately change the values of x and y. Substituting realistic values as actually obtained by Florida factories in recent years for juice extraction and brix and sucrose reduction factors it can be demonstrated that x and y values are 21.058 and 6.150 for sucrose and brix respectively. These values are obtained as follows:

$$\begin{aligned} &29.16667 \times .76 \text{ (normal juice extraction)} \times 0.950 \text{ (sucrose reduction factor)} = \\ &2.1058 \text{ and} \\ &8.3333 \times .76 \text{ (normal juice extraction)} \times 0.971 \text{ (brix reduction factor)} = 6.150. \end{aligned}$$

These factors have the advantage of being directly applicable to the crusher juice brix and sucrose determinations in a very simple process of calculation. The factors can also be converted to % sugar yields by dividing by 2000 and multiplying by 100, i.e., x = 1.052 and y = 0.3075.

The values 21.058 and 6.150 correspond to VCF of 1.00 and are used to calculate indicated yields of sugar per ton of cane for all varieties with milling extraction and sucrose reduction factors comparable to CL 41-223, the standard. It has been demonstrated that the relative values

between any 2 varieties remain constant under a wide range of growing conditions (2, 3, 4). For example, while the actual % of normal juice extracted for any variety varies with the age of the crop, the conditions under which the cane was grown and the milling equipment, the relation between 2 varieties remains essentially constant. Accuracy in measuring relative yields rather than absolute yields is believed to be the important objective in evaluating sugarcane varieties.

The values for x and y given above for C1 41-223 are based on average extraction and reduction factors applied by Florida factories. Since the important consideration is the relative performance of a variety, adjustments could be made in the x and y values without affecting the interpretation of the results although an effort is made to use values that are in reasonably good agreement with those of commercial factories.

The procedure for establishing the VCF consists of milling hand cleaned samples of the test variety and the standard variety, grown under highly comparable conditions, 4 times under hydraulic pressure of approximately 30 tons or 2.143 tons per linear inch of roller. Under the standardized conditions of 20% cold maceration water divided equally among the last 3 millings, extraction of sucrose ranges from 93 - 95%.

Weights and analytical data of the primary (crusher) juice and secondary juice (composited juice plus water from the final 3 millings) supply the necessary information for the calculation of milling results in accordance with conventional methods (7). Percent solids in the juice is determined by brix hydrometer and % sucrose (pol) in juice by polarization of the undiluted juice after clarification with lead sub-acetate. A constant brix reduction factor of .985 is assumed in calculating extraction % cane and other values of normal juice. There is essentially no difference between varieties in brix reduction factor. In addition to the information on juice quantity and quality, we also determine the fiber content in the bagasse in the cane by use of the direct method after diffusing by means of a jet action home washing-machine (5). The bagasse is then dried to constant weight in an oven at 105 C.

The calculation of the VCF is somewhat involved, necessitating the calculation of theoretical sugar yields for the test variety by use of actual normal juice extraction and sucrose reduction values for the test variety and again calculating the yields by use of corresponding values for the standard variety. For example, assuming crusher juice values of 18.46 for brix and 16.76% for sucrose with normal juice extraction of 78.090% for the test variety and 83.853% for C1 41-223 and sucrose reduction factor of 0.974 for test variety and 0.972 for C1 41-223, we proceed as follows:

$$\frac{(16.76 \times 29.16667 \times .78090 \times .974) - (18.46 \times 8.3333 \times .78090 \times .985)}{(16.76 \times 29.16667 \times .83853 \times .972) - (18.46 \times 8.3333 \times .83853 \times .985)} = \frac{253.47}{271.36} = .934$$

The quotient, .934, which is the relation between the test variety and the standard, C1 41-223, is the VCF which is usually rounded off to the nearest even number or .94. The correction factor is applied to the x and y values of the standard variety as follows: $21.058 \times .94 = 19.795$ and $6.150 \times .94 = 5.781$.

Since some of the values used by Arceneaux in calculating VCF are constants, the only variables being normal juice extraction and sucrose reduction factors, the calculations can be simplified by using only the 2 variables in the formula. For example, it can be demonstrated that the value .94 above can be obtained for the same test variety using the same normal juice extraction and sucrose reduction values for the 2 varieties as follows:

$$\frac{.78090 \times .974}{.83853 \times .972} = \frac{.7606}{.8150} = 0.938 \text{ or rounded off to } .94$$

Comparison of the 2 methods of calculating VCF with 91 determinations showed a correlation coefficient of +.985 with only 2 cases in which the difference between the 2 methods was as much as .03. The values were identical in 60 determinations and differed by .01 or .02 in 29 of the comparisons.

We have found that the relationship between extraction values for different varieties grown under different but comparable conditions is usually in good agreement and that an average of 10 determinations usually establishes a constant between the 2 varieties.

A recent survey of milling results obtained at the Florida sugar factories shows that the average percentage of normal juice extraction is 76% and that brix and sucrose reduction factors are .971 and .950, respectively. Using these average values and boiling house efficiency number of 100 we arrive at a value of 21.058 for x and 6.150 for y in the case of variety C1 41-223, the standard which is assigned a VCF of 1.00. For varieties that differ from the standard, the correction factor is applied to both x and y values, i.e. when the VCF is .96 the corresponding values of x and y are 20.215 and 5.904. To calculate the theoretical yield of 96° sugar per ton of cane from crusher juice of C1 41-223 with the 18.00 brix and 16.25 sucrose we proceed as follows: $(16.25 \times 21.058) - (18.50 \times 6.150) = 228.4 \text{ lb.}$

Commercial varieties in Florida with a VCF of 1.00 are CP 56-63, CP 63-306, and CP 63-588. CP 57-603 has a VCF of 1.02; CP 62-374 a factor of 1.04 and CP 50-28, CP 59-73 and L 61-49 have a factor of .94.

In routine variety evaluation for milling quality, duplicate samples of 6 - 8 varieties, including the standard, all grown under comparable conditions, such as a replicated variety test, are milled under the conditions described above. Cl 41-223 has been the standard because it is the most widely-grown variety in Florida. In recent years, CP 63-588, a variety with milling qualities comparable to those of Cl 41-223, has been substituted as the standard in our yield tests. In an effort to determine the reliability of CP 63-588 as a check in milling tests, an experiment involving 5 commercial varieties in 8 tests over a period of 3 harvest seasons was conducted at the Canal Point station.

Tables 1 and 2 give the results of this experiment with 16 determinations of each variety for normal juice extraction, crusher juice extraction, sucrose reduction factor, fiber in cane, VCF and % of sucrose in the crusher juice. This table shows that both CP 56-63 and CP 63-588 are essentially equal to Cl 41-223 with respect to normal juice extraction, crusher juice extraction and sucrose reduction factor. Although CP 63-588 is higher in fiber than either Cl 41-223 or CP 56-63, it is assigned a VCF of 1.00 because it equals the standard in the parameters used in determining this value.

Table 1. Results of complete milling tests with 5 varieties in Florida from 1969 to 1971. Average of 16 determinations.

Variety	: Normal juice : extraction (%) :	Crusher juice		: Sucrose reduction : factor :	: Fiber in : cane (%) :	: VCF
		: Extraction : % :	: Sucrose : % :			
Cl 41-223	81.9	55.5	15.3	.972	8.72	1.000
CP 56-59	78.5	52.2	14.8	.970	11.17	.953
CP 56-63	82.1	56.0	16.5	.973	8.92	1.000
CP 59-73	76.8	47.8	15.0	.970	11.95	.934
CP 63-588	81.0	55.9	15.2	.973	9.74	.990

Table 2. Correlation coefficients between characters with 5 varieties.

	Cl 41-223	CP 56-59	CP 56-63	CP 59-73	CP 63-588	Average
Normal juice extraction and VCF	.248	.717	.700	.420	.814	.580
Normal juice extraction and fiber	-.151	-.579	.134	-.052	-.400	-.230
Normal juice extraction and crusher juice extraction	.028	.608	-.401	.208	.641	.206
Sucrose reduction factor and VCF	.390	.377	.142	.067	.389	.275
VCF and fiber	-.171	-.488	.039	-.120	-.151	-.178
VCF and crusher juice extraction	.419	.501	-.148	.501	.750	.405
Fiber and sucrose content	.250	.337	.241	.455	-.232	.210
Fiber and crusher juice extraction	.161	-.753	-.276	-.423	-.251	-.308

The absence of a perfect correlation between fiber content and juice extraction shows the need for using conventional milling equipment in evaluating milling quality. The characteristics, as well as amount, of fiber should be taken into consideration.

The determination of normal juice extraction is difficult and requires specialized equipment. Crusher juice extraction can be determined much more easily and rapidly. A close relationship exists between normal juice and crusher juice. During the 1971-72 harvest season, complete milling tests were conducted with 45 varieties ranging from 64.3 - 86.1% in normal juice extraction and from

6.75 - 18.74% in fiber content. Correlation coefficients between all possible combinations of normal juice extraction, crusher juice extraction, fiber content, sucrose content of crusher juice, sucrose reduction factor and VCF were calculated, and the results are presented in Table 3.

Table 3. Correlation coefficients (r) among characters with 45 clones.

	: Crusher juice : extraction	: Sucrose reduction : factor	: Sucrose in : crusher juice	: Fiber : content	: VCF
Normal juice extraction	.897	-.086	.109	-.775	.919
Crusher juice extraction		.086	.168	-.699	.892
Sucrose reduction factor			.002	-.023	-.023
Sucrose in crusher juice				-.296	.296
Fiber content					-.808

The highest correlation coefficient was obtained between normal juice extraction and VCF ($r = .919$). This was expected because the latter value is partially based on normal juice extraction. Two other associations of interest in variety evaluation are those between normal juice and crusher juice, ($r = .897$) and between crusher juice and VCF, ($r = .892$). The negative correlation between normal juice extraction and fiber content ($r = -.775$) is high, but as discussed above, the quantity of fiber is not always the determining factor in juice extraction by conventional mill rollers.

Although the correlation coefficient for association between normal juice and crusher juice extraction is very high, ($r = .897$) indicating a close relationship, there were many exceptions to this association. For example, Table 4 shows that for 3 rates of normal juice extraction, 78, 80, and 83%, there were wide ranges in the percentage of crusher juice obtained. Five of the 45 clones tested yielded 78% normal juice extraction and the same five varieties ranged from 41.4 - 54.1% in crusher juice extraction. The difference is approximately 30%. At 80% normal juice extraction, the amount of crusher juice extracted ranged from 53.5 - 57.5%, and at 83% normal juice extraction the crusher juice extracted ranged from 54.0 - 58.8%.

Table 4. Range of crusher juice obtained at 3 rates of normal juice extraction with 45 clones during the 1971-72 harvest season.

Normal juice extraction %	Crusher juice extraction range %
78.0	41.4 - 54.1
80.0	53.5 - 57.5
83.0	54.0 - 58.8

At a given value of normal juice the percentage of crusher juice obtained varied by 8 - 20% for the 5 commercial varieties in the experiment (data not shown). For example, 7 of the 16 samples of CP 56-63 yielded 71% in the amount of normal juice extracted, and the 7 samples ranged from 51 - 55% in the amount of crusher juice extracted. This 4% difference is equal to a difference of approximately 8% if based on the 51% crusher juice extraction value. Cl 41-223 ranged from 46 - 55%, a difference of 20% in amount of crusher juice extracted when the normal juice extracted was 81%.

While preliminary crusher juice determinations are of value in the elimination of varieties of low juice content, more precise information is necessary for reliable evaluation of milling quality. The same observation can be made for fiber determination. Although there is a close association between quantity of fiber and juice, the quality of the fiber and its ability to retain juice, hence, sucrose should also be determined. Two varieties with equal amounts of fiber frequently have different extractions of normal juice. Needless to say, the cane samples being evaluated should be comparable in age and in amount of extraneous material such as leaves or leaf sheaths which affect the amount and quality of extractable juice.

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DEMONSTRATED AND POTENTIAL CONTROL OF THE SUGARCANE
BORER^{1/} IN FLORIDA BY THE CUBAN FLY, Lixophaga diatraeae^{2/}

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ABSTRACT

The release of 1000 adult Cuban flies, Lixophaga diatraeae, a parasite of the sugarcane borer, Diatraea saccharalis, in a 10-acre block of sugarcane resulted in 1.51% joints being bored after the date of parasite release. This compared with 2.66% joints bored in non-release control areas during the same period. Possibilities for suppressing sugarcane borer populations by massive strategic releases of Lixophaga diatraeae are discussed.

Editors note: Only the Abstract of this paper was available for the Proceedings.

^{1/} Lepidoptera: Pyralidae.

^{2/} Diptera: Tachinidae.

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EFFECT OF SOME SOIL PESTICIDES ON SUGARCANE YIELDS IN FLORIDA

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ABSTRACT

A replicated field plot test comparing 3 rates of Parathion, Dyfonate, Dasanit, Furadan, and Diazinon applied at planting time was initiated in November 1970. Pretreatment sampling indicated a large population of wireworms (Melanotus communis) in the plot area, while nematode samples revealed relative low numbers. Stand counts showed that Parathion and Diazinon plots had lower plant populations at 6 months than the other treatments, although they had ranked among the highest at 6 weeks. Furadan plots were among the lowest at 6 weeks, but ranked 1st, 2nd, and 4th at 6 months. Yields of sugar per acre for all chemical treatments were significantly greater than the check plots. All Furadan treatments had statistically higher yields of sugar per acre than the following: all Diazinon treatments, 2 Dasanit treatments, and 1 Parathion treatment. There were no significant differences between rates of a given material. A cost-return analysis showed a comparison between the cost of materials and returns that might be expected, based on the yields from this test. Furadan 10G gave the highest yields of sugar per acre, and also gave the greatest return in increased yield over the cost of the chemical. The 2 most commonly used treatments during the past 5 years, i.e., Parathion 10G at 60 lb/acre and Diazinon 14G at 42 lb/acre, ranked very low in both yield of sugar per acre and in the cost-return comparison. This test clearly demonstrates the value of soil insecticide treatment to plant cane in Florida.

INTRODUCTION

Wireworms and nematodes are common soil pests of sugarcane in Florida. The economic importance of the wireworm (Melanotus communis) is well known to all Florida growers that have planted sugarcane without some cultural or chemical attempt to control this pest (1).

Nematodes have also damaged sugarcane in Florida (3). However, the amount of damage throughout the industry is not known.

Parathion and Diazinon were the only materials available to the cane grower for a number of years. Recently, several new materials which have different modes of action, different chemical and physical properties, and a wide variation in cost/acre for treatment have been registered for either wireworm control, or nematode control, or both in sugarcane.

The purpose of this study was to observe the effect on sugarcane yields and obtain cost return comparison for these materials under the conditions of a replicated test. Hopefully the results would aid the sugarcane grower in selecting a material and rate that will give the most profitable returns.

MATERIALS AND METHODS

The test area selected was on Hatton Brothers farm approximately 9 miles east of Canal Point, Florida. The field selected had been in Bahia grass pasture for the previous 6 years. It was mechanically fallowed to reduce grass, weeds, wireworms, and nematodes in preparation for planting.

The test was in a randomized complete block design with 3 replications. Each plot contained 4 rows 50-ft long for a total of 200 row ft (1/43.56 acres). The sugarcane variety used was Cl 41-223.

Wireworm populations were estimated by counting the number collected from sweet corn ear baits buried and left in the test area for 11 days before the chemical treatments were applied. Ten ears were buried randomly at a depth of 12" and 10 ears at 24".

Six composite soil samples taken prior to planting and treating were analyzed for nematodes.

Materials included in this test were Parathion 10G, Diazinon 14G, Dyfonate 10G, Dasanit 15G, and Furadan 10G. Parathion, Diazinon and Dyfonate are registered for control of wireworms in sugarcane. Dasanit is registered for control of nematodes and Furadan is registered for control of both wireworms and nematodes. All materials were used at 3 rates and hand applied in a 12 - 15" band over the top of the seed cane in the open furrow on November 4, 1970 and covered the same day. A pint jar with holes punched in the lid was used to distribute the chemicals. Materials for each row were pre-weighed in the laboratory, and several passes were made over each row until all the chemical was applied.

All plots were covered, using a commercial covering rig which had been applying Furadan 10G at 40 lb/acre. This rig inadvertently covered 2 rows of 1 plot of each of these treatments with the 40 lb/acre rate of Furadan in addition to the test materials already applied: Furadan 30 lb/acre, Parathion 20 lb/acre, Check, Furadan 20 lb/acre and Diazinon 28 lb/acre.

Stand counts for each plot were made 6 weeks and 6 months after planting. The juice analysis for each plot was determined from 10 stalks selected at random and cut on January 24, 1972. The stalks were milled on January 25, and brix and pol were determined by the sugar lab at the Agricultural Research and Education Center, Belle Glade. All plots were cut and weighed on February 7, 1972. The number of millable stalks/plot was estimated using the total plot weight and the average stalk weight. Stand counts and juice analysis were adjusted for the plots that had been over-treated with Furadan 10G at 40 lb/acre.

Brix, pol and plot weights were used in estimating the tons of sugar/acre produced by each treatment (2). The tons of sugar/acre were converted to standard tons of cane/acre. The value of standard tons of cane/acre and chemical costs were used in making a cost-return analysis.

RESULTS AND DISCUSSION

Wireworm sampling results. No attempt was made to convert wireworm counts into population numbers/acre. The authors consider the average of 6.7 wireworms/bait ear of corn to be sufficient to cause serious damage to plant cane. Low yields from the check plots support this hypothesis.

Nematode sampling results. The nematode population was found to be very low in the test area. The spiral nematode (*Helicotylenchus* sp.), the ring nematode (*Criconemoides* sp.) and the stunt nematode (*Tylenchorhynchus* sp.) were the only plant parasitic nematodes present.

Based on current knowledge of these nematodes, the populations were too low to cause serious injury to the young cane plants. The practice of fallowing the land for a number of months before planting will reduce nematode populations and was thought to be the contributing factor here. However, these nematodes can repopulate rapidly and could become a problem in future stubble crops.

Stand counts and millable stalks/plot. Results of the stand counts at 6 weeks and 6 months and the estimated millable stalks are shown in Table 1. The most interesting aspect of these data is that plots with high stand counts early had low counts at 6 months and harvest. Diazinon at 28 lb/acre had the most stalks at 6 weeks, but ranked 9th at 6 months and 12th at harvest. Similarly, all Parathion treatments ranked in the upper half of the plots at 6 weeks, but were in the lower half at 6 months and harvest. All Furadan treatments ranked low at 6 weeks, but ranked 1st, 2nd, and 4th at 6 months and 1st, 2nd, and 3rd at harvest. Dasanit at 23.3 lb/acre followed a pattern similar to the Furadan treatments. It ranked 12th at 6 weeks, but was 3rd at 6 months and 8th at harvest. Dyfonate was fairly consistent and ranked in the upper half throughout the test. The check plot was poorest in every instance, ranking 16th throughout.

Table 1. Stand counts during growing season and calculated millable stalk count at harvest.

Treatment	lb/acre	Number stalks/plot		Calculated millable stalks/plot February 7, 1972 (harvest)
		December 22, 1970 (6 weeks)	May 24, 1971 (6 months)	
Furadan 10G	40	232 (8) <u>1/</u>	745 (2) <u>1/</u>	604
Furadan 10G	30	204 (13b)	737 (4)	567
Furadan 10G	20	222 (11)	775 (1)	566
Dyfonate 10G	40	248 (5)	701 (6)	565
Diazinon 14G	42	229 (9)	628 (8)	552
Dyfonate 10G	30	266 (2)	720 (5)	543
Parathion 10G	60	257 (3)	588 (12)	542
Dasanit 15G	23.3	209 (12)	744 (3)	534
Dyfonate 10G	20	252 (4)	668 (7)	513
Parathion 10G	40	234 (7)	578 (13)	487
Parathion 10G	20	238 (6)	568 (14)	475
Diazinon 14G	28	270 (1)	627 (9)	474
Dasanit 15G	13.3	203 (15)	589 (11)	472
Dasanit 15G	33.3	226 (10)	612 (10)	470
Diazinon 14G	14	204 (13a)	450 (15)	415
Check	--	91 (16)	189 (16)	335

1/ Numbers in parenthesis indicate ranking of stand counts.

Lb of sugar/acre. The lb of sugar/acre calculated from the plot yields are shown in Table 2. Statistically, the check was significantly lower in yield than all chemical treatments. This clearly shows the value of soil insecticide treatments when wireworm infestations are high.

Table 2. Calculated yields of tons of cane/acre, sugar/ton of cane, and sugar/acre for each treatment.

Treatment	lb/acre	Tons cane/acre	Yield of 96° sugar	
			lb/ton of cane	lb/acre
Furadan 10G	40	50.64	200.7	10,157 a <u>1/</u>
Furadan 10G	20	46.17	218.7	10,116 a
Furadan 10G	30	49.08	205.3	10,098 a
Dasanit 15G	23.3	44.10	219.3	9,755 a b
Dyfonate 10G	40	47.10	196.0	9,728 a b
Dyfonate 10G	30	43.74	204.7	8,989 a b c
Parathion 10G	40	40.40	220.3	8,934 a b c
Dyfonate 10G	20	40.15	211.7	8,586 a b c
Parathion 10G	20	37.90	213.7	8,122 a b c
Dasanit 15G	13.3	37.54	211.7	7,994 b c
Diazinon 14G	42	38.00	207.0	7,942 b c
Diazinon 14G	28	37.90	207.0	7,936 b c
Dasanit 15G	33.3	38.59	205.3	7,932 b c
Parathion 10G	60	39.17	201.0	7,873 b c
Diazinon 14G	14	33.03	220.7	7,343 c
Check	--	22.11	190.7	4,194 d

1/ Means followed by same letter are not significantly different at the 5% level of probability using Duncan's Multiple Range Test.

Statistically there were few differences between the chemical treatments. The most important statistical difference was that all Furadan treatments had yields significantly greater than all Diazinon treatments. Furadan yields were also significantly greater than 2 Dasanit treatments, and one Parathion treatment.

There was no significant difference between rates of a particular material; however, the high rates of Parathion and Dasanit gave lower yields than their lower rates. Growers should use caution not to overtreat, as the higher rates of some materials may actually reduce yields as seen in Table 2.

Cost-return. Table 3 presents a cost-return comparison of all treatments tested. The exact price of insecticide granules will vary with time and among dealers, and the yield from a given treatment in commercial fields will probably not be the same as the yields from these small plots. However, the comparisons between different treatments is the item we wish to stress.

Table 3. Cost-return comparisons based on standard tons of cane/acre and chemical costs/acre.

Treatment	Insecticide lb/acre	Cost \$/acre	Standard tons cane/ acre	\$ value of cane/acre ^{1/}	Dollar increase over check/acre	Dollar increase less cost of material
Furadan	20	9.00	54.30	597	349	340
Furadan	30	13.40	54.20	596	348	335
Furadan	40	18.00	54.52	600	352	334
Dasanit	23.3	10.25	52.36	576	328	318
Dyfonate	40	14.00	52.22	574	326	312
Parathion	40	3.60	47.96	528	280	276
Dyfonate	30	10.50	48.25	531	283	273
Dyfonate	20	7.00	46.09	507	259	252
Parathion	20	1.80	43.60	480	232	230
Dasanit	13.3	5.85	42.91	472	224	218
Parathion	60	5.40	42.30	465	217	212
Diazinon	28	9.52	42.60	469	221	211
Dianizon	42	14.28	42.63	469	221	207
Dasanit	33.3	14.65	42.58	468	220	205
Diazinon	14	4.76	39.41	434	186	181
Check	--	--	22.51	248	--	--

^{1/} Standard sugarcane value of \$11.00/ton.

The ranking in the cost-return Table 3 is similar to that of the theoretical yield, Table 2. Furadan at the 20 lb/acre rate gave the largest return in increased yield over the added cost of the granules.

It is interesting to note that the 2 most commonly used treatments during the last 5 years, i.e., Parathion 60 lb/acre and Diazinon 42 lb/acre, are close to the bottom in yield and return.

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SOIL-INCORPORATED TRIFLURALIN FOR CONTROLLING WEEDS IN SUGARCANE

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ABSTRACT

Since 1965, a,a,a-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine (trifluralin) has been investigated for its applicability to selective weed control in sugarcane (hybrids of the genus Saccharum). A commercially available rolling cultivator was modified to incorporate trifluralin into the soil. This implement apparently did not excessively injure sugarcane 8-12" tall, but actual effects on yield were not measured. Trifluralin was incorporated into soil with implements set to cut 2-3" deep either immediately before or immediately after fall planting of sugarcane to a depth of 4". Yield of sugar/acre was not affected in one experiment by trifluralin whether applied preplant or postplant at rates up to 3 lb/A; however, the weed control was less satisfactory with preplant treatments. Since sugarcane has been injured when planted directly in trifluralin-treated soil, postplant treatments seem safer than preplant treatments. Fall applications of trifluralin incorporated at 2 lb/A effectively controlled henbit (Lamium amplexicaule L.) and chickweed (Stellaria media (L.) Cyrillo) during the winter but did not effectively control wild carrot (Daucus carota L.) or Carolina geranium (Geranium carolinianum L.). It did not effectively control scarlet morningglory (Ipomoea coccinea L.) or several other summer broadleaf weeds during the summer. Spring applications of trifluralin incorporated at 2 lb/A were highly effective for selective preemergence control of grass weeds - johnsongrass (Sorghum halepense (L.) Pers.) from seed, junglerice (Echinochloa colonum (L.) Link), crabgrass (Digitaria sanguinalis (L.) Scop.), and itchgrass (Rottboellia exaltata L.f.).

When compared with standard herbicide treatments for preemergence weed control, trifluralin was less effective for control of broadleaf weeds, equally effective for control of johnsongrass and annual grasses, but much more effective for control of itchgrass.

INTRODUCTION

Trifluralin has been used commercially since 1963, primarily as a preplant, soil-incorporated treatment for many dicotyledonous agronomic and horticultural crops. It has been widely used in cotton (Gossypium sp.) and soybean (Glycine max (L.) Merr.) for the preemergence control of johnsongrass and other grasses growing from seed. Incorporation of trifluralin into soil has been suggested by the manufacturer because of its volatile nature and because weed control is more effective and consistent (5). Soil incorporation effectively reduces loss of trifluralin by vaporization into the air (1). Trifluralin is toxic to both roots and shoots of sensitive plants but the shoot of emerging seedlings is most sensitive (2,6).

Use of trifluralin in sugarcane posed several problems not encountered in other crops. In preliminary, unpublished studies, we found that sugarcane did not have a strong physiological tolerance to trifluralin because it was injured when seed pieces were planted directly in trifluralin-treated soil. Also, in Louisiana, sugarcane is planted primarily in the fall, but johnsongrass and itchgrass, the principal grass weeds, are not a problem until spring, about 5 months later. For spring applications, special incorporation equipment is needed for use over emerged sugarcane. In this study, we applied trifluralin before and after planting in the fall and over emerged cane in the spring to develop methods of application that would give selective weed control.

MATERIALS AND METHODS

Three field experiments, involving randomized complete blocks with 5 or 6 replications, were conducted on silt or silty clay loam during 1965-66 (Experiment 1), 1966-67 (Experiment 2), and 1970 (Experiment 3). In Experiments 1 and 2, fields were newly planted to cane and infested with seeds of annual winter and summer weeds and of johnsongrass. Sugarcane was planted in September at a standard depth of about 4". In Experiment 3, the field treated carried a 1st stubble crop of sugarcane that had been heavily infested with itchgrass as plant cane the previous year.

In Experiment 1, trifluralin at 1, 2, or 3 lb/A was applied either 10 days before planting (preplant) or immediately after planting (postplant) sugarcane cultivar CP 55-30. The 1 and 2 lb/A rates were reapplied in March, before the weeds and after the cane had emerged. The 3 lb/A rate was not reapplied in the spring in order to determine the effect of the single fall application on yield and on weed control the following year.

In Experiment 2, trifluralin was applied as fall + spring treatments and as single spring treatment. For fall + spring treatments, trifluralin at 1, 1.5, or 2 lb/A, or a mixture of trifluralin at 1 lb/A + silvex at 2 lb/A, was applied immediately after planting sugarcane cultivar CP 52-68. These treatments were then reapplied in March before the weeds and after the cane had emerged. In the single spring treatments, silvex at 2 lb/A was applied to soil immediately after planting in September to provide some control of winter weeds. Then, trifluralin at 1, 2, or 3 lb/A was applied in March at the same time as the fall + spring treatments. Plots having abundant winter weeds were hand hoed before herbicides were applied in the spring.

In Experiment 3, to permit incorporation, the stubble of cultivar CP 52-68 was shaved to ground level with a rotary blade shaver and the soil loosened before applying the herbicide preemergence to itchgrass in March. Trifluralin was applied at 1.5, 2, or 3 lb/A.

In each experiment, trifluralin treatments were compared with one or more standard herbicide treatments: (2,3,6-trichlorophenyl)acetic acid (fenac) at rates of 3.6 or 4.5 lb/A applied alone or mixed with 2-(2,4,5-trichlorophenoxy)propionic acid (silvex) at 2.4 or 3 lb/A; 3-*tert*-butyl-5-chloro-6-methyluracil (terbacil) at 3.2 lb/A; or two applications of a mixture of sodium salt of trichloroacetic acid (TCA) at 5 or 10 lb/A and silvex at 3 lb/A + (for the second application only) sodium salt of 2,2-dichloropropionic acid (dalapon) at 4.5 lb/A. Commercial formulations of all herbicides in water were sprayed on a 36" band centered over the top of the bed where sugarcane was planted.

Trifluralin treatments were incorporated into soil 15-30 min. after spraying, with implements set to cut 2-3" deep. Because these implements could not be operated efficiently in a small plot, we sprayed trifluralin treatments and ran the incorporating implement over all plots in the experiment and immediately afterward sprayed the standard herbicide treatments. A 4-ft, power-driven rotary tiller was used to incorporate herbicides in preplant treatments in Experiment 1, and a rolling-cultivator type implement was used to incorporate herbicides in postplant and spring treatments in all experiments. The latter implement was a Lehman-Lilliston Rolling Cultivator with four 16" gangs of 5 curved tines per gang. Two gangs were placed in tandem to roll over the top of the bed, including the sugarcane if emerged and 1 gang was placed on each side to just overlap the center gangs. The gangs were adjusted to till the soil without excessively injuring sugarcane when the implement was operated at 5 mph. In the spring, the soil was loosened with a rolling cultivator before trifluralin was applied and incorporated.

Control of johnsongrass or itchgrass was measured by actual counting. Control of winter broadleaf, summer broadleaf, and summer grass weeds was estimated. Weeds were removed after weed control ratings to minimize competition with cane. Crop tolerance to herbicides in Experiments 1 and 2 was based on yields obtained at harvest in the fall.

RESULTS AND DISCUSSION

The infestation of weed species varied among experiments. The primary winter weeds in Experiment 1 were henebit, chickweed, and purslane speedwell (*Veronica peregrina* L.), and in Experiment 2, these weeds and Carolina geranium and sporadic infestations of some crucifers and composites. The johnsongrass seedling infestation in the spring in both experiments 1 and 2 was a moderate 450 plants/1000 sq ft. Summer annual grasses were primarily crabgrass and junglerice in Experiment 1 but were too few to evaluate in Experiment 2. Summer broadleaf weeds were prevalent only in Experiment 2 and consisted mainly of alligatorweed (*Alternanthera philoxeroides* (Mart.) Griseb.), scarlet morningglory, common purslane (*Portulaca oleracea* L.), and Virginia cooper leaf (*Acalypha virginica* L.).

Trifluralin applied preplant in Experiment 1 did not control winter weeds as effectively as trifluralin applied postplant (Table 1). A single 3 lb/A rate in the fall also was less residual as a preplant than postplant treatment, as measured by the control of johnsongrass and summer grasses during the following spring and summer. The movement of soil during planting evidently diluted the concentration of trifluralin applied preplant. Weed control from residual trifluralin after 5 months would not ordinarily be expected because field experiments by others have shown that only about 10% of the trifluralin applied is still present after this period (4).

Table 1. Effect of preplant and postplant applications of trifluralin on weed control and yield of sugarcane (Experiment 1).

Herbicide	Time & rate (lb/A)			Weed control			Yield of	Yield of 96° sugar ^{2/}	
	Fall		Spring	Winter	Johnson-	Summer	cane per	Per ton	Per
	Preplant	Postplant		:broadleaf:	grass	:grasses	: acre ^{2/}	: of cane	: acre
				%	%	%	tons	pounds	pounds
Trifluralin	1.0	-	+ 1.0	33	70	93	33	174	5645
Trifluralin	-	1.0	+ 1.0	94	92	98	34	174	5954
Trifluralin	2.0	-	+ 2.0	66	90	98	33	174	5787
Trifluralin	-	2.0	+ 2.0	96	99	100	33	174	5729
Trifluralin	3.0	-	+ 0	84	32	45	31	171	5338
Trifluralin	-	3.0	+ 0	98	79	64	33	169	5634
Fenac	-	4.5	+ 4.5 ^{1/}	99	94	100	33	172	5662
Hoed check	-	-	+ -	-	-	-	32	170	5450

1/ Standard herbicide check.

2/ No significant difference at the 5% level of probability.

A comparison of broadleaf weed control in Experiments 1 and 2 (Tables 1 and 2) shows that trifluralin does not control as wide a range of broadleaf species as does fenac. In the winter, trifluralin applied postplant effectively controlled henbit, chickweed, and purslane speedwell in both experiments but did not effectively control wild geranium, wild carrot, and a few other species in Experiment 2. In the summer, trifluralin also was inferior to fenac for control of scarlet morning-glory and several other broadleaf species in Experiment 2 (Table 2).

Table 2. Effect of fall plus spring and single spring applications of trifluralin on weed control and yield of sugarcane (Experiment 2).

Herbicide (lb/A) by time applied	Weed control			Yield of	Yield of 96° sugar ^{2/}	
	Winter	Johnson-	Summer	cane per	Per ton	Per
	:broadleaf:	grass	:broadleaf:	: acre ^{2/}	: of cane	: acre
	%	%	%	tons	pounds	pounds
Fall						
Spring						
Trifluralin - 1.0 + Trifluralin - 1.0	55	96	36	36	189	6758
Trifluralin - 1.0 + Trifluralin - 2.0	55	99	57	35	194	6767
(Trifluralin- 1.0 + (Trifluralin- 1.0						
+ Silvex - 2.0) + Silvex - 2.0)	66	99	60	35	190	6725
Trifluralin - 1.5 + Trifluralin - 1.5	60	98	53	35	192	6823
Trifluralin - 2.0 + Trifluralin - 2.0	63	99	60	36	183	6524
Silvex - 2.0 + Trifluralin - 1.0	56	96	36	35	187	6592
Silvex - 2.0 + Trifluralin - 2.0	55	98	43	36	197	7092
Silvex - 2.0 + Trifluralin - 3.0	53	98	57	35	192	6751
(Fenac - 3.6 + (Fenac - 4.5 ^{1/}						
+ Silvex - 2.4) + Silvex - 3.0)	100	98	100	36	190	6750

1/ Standard herbicide check.

2/ No significant difference at 5% level of probability.

Trifluralin was highly toxic to grass weeds. Either fall + spring or single spring treatments at about 2 lb/A controlled johnsongrass and summer grasses as effectively as a fall + spring application of fenac (Tables 1 and 2). It was much more effective than fenac, or TCA + silvex + dalapon, or terbacil for control of itchgrass (Table 3). Trifluralin has been the only herbicide evaluated to date that has been effective for selective preemergence control of itchgrass in sugarcane.

Table 3. Control of itchgrass in sugarcane with trifluralin soil-incorporated in March (Experiment 3).

Herbicide (lb/A)	No. of surviving plants per 100 sq ft by month of germination			Seasonal control
	April	May	June	
				%
Trifluralin - 1.5	7	15	30	93
Trifluralin - 2.0	6	11	14	97
Trifluralin - 3.0	0	2	5	99
Terbacil - 3.2	111	142	150	66
Fenac - 4.5	73	94	102	77
(TCA - 10.01/ + Silvex 3.0)	68	94	116	74
Untreated check ^{2/}	295	370	444	-

^{1/} A second application of TCA - 5.0 + dalapon - 4.5 + silvex - 3.0 was made in early May. A standard practice check.

^{2/} Weeds removed each month after weed ratings.

Trifluralin seems exceptionally safe for use on sugarcane since yields of cane and sugar from these treatments were equivalent to yields from the standard fenac treatment (Tables 1 and 2). Even preplant applications of trifluralin did not lower yields; under less controlled conditions, conceivably, a sufficient concentration of trifluralin might be moved into the root zone during planting to be phytotoxic.

Yields are not a measure of injury caused by incorporation equipment because the entire experiment was subjected to the same treatment. Sugarcane had not emerged in the fall but no injury to seed pieces was observed. In the spring, shoots 8-12" tall were damaged by being mashed down and pricked by the tines; however, the shoots seemed to recover quickly and no permanent injury was noted. Doubtless, injury from the implement would increase as size of sugarcane increased. The rolling-cultivator type implement cannot be used for incorporation on stubble cane without first shaving off the old stubble to ground level. Shaving may reduce yields of sugarcane, particularly if stubble is shaved late in the spring after new shoots have made substantial growth (3). Therefore, incorporation or shaving plus incorporation would be expected to cause the least injury to sugarcane when shoots are small (probably during March in Louisiana).

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THE EFFECT OF AGRICULTURAL LIME AND GROUND ROCK PHOSPHATE
ON YIELD OF SUGARCANE, SOIL pH AND P AND Ca EXTRACTABLE
FROM BALDWIN SILTY CLAY LOAM SOIL

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ABSTRACT

An experiment was conducted on Baldwin silty clay loam to determine the effect of lime and rock phosphate on yields of sugarcane and sugar, on soil pH and on P and Ca extractable from the soil. A total of 5 crops was harvested in the experiment. Lime, applied at the rate of 3 tons per acre, resulted in a highly significant increase in the average yield of cane and a significant increase in the average yield of sugar per acre. Significant increases in average yields of cane and sugar per acre were obtained due to application of 1 ton per acre of rock phosphate. Increases in average cane yields per acre from the lime, rock phosphate and lime plus rock phosphate treatments were 1.98, 1.12 and 2.01 tons per acre, respectively, and increases in average sugar yields per acre from the treatments were 346, 322 and 432 lb per acre, respectively. The greatest effect of treatments on soil pH and on extractable P and Ca occurred in 1965, the 3rd crop year, following application of rock phosphate and lime. The soil pH values from the check, lime, rock phosphate and lime plus rock phosphate treatments were 4.9, 6.1, 5.1 and 6.3, respectively. In 1965, the increase in P extractable from the rock-phosphate-treated soil, 115 ppm, was equivalent to 78% of the amount applied. The increase in P extractable from the lime plus rock phosphate treatment, 183 ppm, was equivalent to 124% of the amount of phosphorus applied. The increase in Ca extractable from the lime-treated soil, 1342 ppm, was equivalent to approximately 58% of the amount applied, and the increase from the lime plus rock phosphate treatment, 1513 ppm, was equivalent to approximately 66% of the amount applied. It was concluded that beneficial effects from liming acid soils should occur throughout 2 cycles of sugarcane crops of 2 - 3 crops per cycle. Application of rock phosphate at the rate of 1 ton per acre may be of benefit for several cycles of crops when applied to soils of moderate to strong acidity, but may result in little effect on yield when the soil pH is above 6.0.

INTRODUCTION

Davidson (2) reported results from 4 experiments conducted in Louisiana from 1938 - 1946 to determine the effect of agricultural lime on yields of sugarcane and sugar. Data from the experiments, representing 17 crops of cane, showed that use of 3 tons of lime per acre caused a significant reduction in sucrose percent juice, amounting to 0.25, and significant increases in yield, 2.59 tons of cane and 373 lb of sugar per acre.

Rodriguez (9), in Trinidad, reported that liming an acid soil caused a marked increase in the uptake of P by sugarcane.

The practice of applying rock phosphate to soils cropped to sugarcane has been limited. Studies of the effectiveness of rock phosphate, however, indicate that this cheaper form of phosphate should be used where large amounts are required on acid soils (7). Rock phosphate mixed with soils of pH 4.0 and 5.0 was consistently more effective than rock phosphate banded in the soil, and no difference in the effect of mixed and banded treatments was noted when the soil pH was 6.0 (7).

MATERIALS AND METHODS

An experiment was conducted on Baldwin silty clay loam on O'Neil Plantation, Franklin, Louisiana, to determine the effect of lime and rock phosphate, applied alone and in combination, on yields of cane and sugar, on soil pH and on extractable P and Ca. The CaCO_3 equivalent of the lime was 98%, and 58% of the material passed a 100-mesh sieve. The rock phosphate contained P equivalent to 34% P_2O_5 and 82% passed a 100-mesh sieve.

The lime, at the rate of 3 tons per acre, was broadcast by machine; the rock phosphate, at the rate of 1 ton per acre, was broadcast by hand. The treatment materials were incorporated in the top-soil by fallow plowing and row-building operations during the summer of 1962. The experiment was a 2 x 2 factorial with 3 replications. Individual plot size was 0.094 acre. The 4 rows used in each plot were separated from adjacent plots by 4 buffer rows. Plant cane and the 1st and 2nd stubble crops were harvested in 1963, 1964 and 1965, and plant cane and 1st stubble crops were harvested in 1967 and 1968. Fertilizer N and K were applied at a constant rate over the experimental site in the spring of each crop year. The rate of N varied from 100 - 160 lb per acre and the rate of K was equivalent to 80 lb of K_2O per acre.

Soil samples were obtained in the spring of each crop year. The P was extracted with a solution of 0.1 N HCl + 0.03 N NH₄F, and the Ca was extracted with a solution of 0.1 N HCl (1).

All of the cane produced in each plot was cut by mechanical means and weighed. Sucrose was determined from 15-stalk samples obtained from each plot.

RESULTS AND DISCUSSION

Yields obtained in the experiment are reported in Table 1. Results from analysis of variance of the data showed a highly significant increase in average yield of cane and a significant increase in average yield of sugar due to lime. Significant increases in average yield of cane and sugar were obtained due to rock phosphate. The F value for lime x rock phosphate interaction effects on average cane yield was 3.79, but an F value of 4.10 was required for statistical significance. Lime x rock phosphate interaction effects on average sugar yield were not statistically significant.

Table 1. The effect of application of agricultural lime and ground rock phosphate on yield of sugarcane and sugar in an experiment on Baldwin silty clay loam soil at O'Neil Plantation.

Treatment	Year					Average Yield	Average increase over check
	1963	1964	1965	1967	1968		
Yield of sugarcane, net tons per acre							
Check	28.63	23.48	24.95	35.01	30.43	28.50	-
Lime	30.67	25.28	28.37	36.13	31.97	30.48	1.98
Rock phosphate	29.86	24.59	26.66	35.35	31.65	29.62	1.12
Lime plus rock phosphate	30.83	24.05	27.33	38.01	32.31	30.51	2.01
Yield of sugar, pounds per acre							
Check	6126	4431	4708	6372	5299	5387	-
Lime	6382	4702	5348	6720	5515	5733	346
Rock phosphate	6671	4407	5100	6621	5746	5709	322
Lime plus rock phosphate	6302	4247	4988	7575	5983	5819	432

The average increases in yield from the 5 crops, 1.98 tons of cane and 346 lb of sugar per acre, due to 3 tons of lime applied alone, are close to the averages obtained by Davidson (2).

Average increases in yield, 1.12 tons of cane and 322 lb of sugar per acre, were obtained due to rock phosphate applied alone.

Results from soil analyses are shown in Fig. 1, 2 and 3. The greatest effect of treatments on soil pH and extractable P and Ca occurred during the 3rd crop year in 1965.

It may be seen in Fig. 1 that in 1968 the pH values of soils which received lime were approaching the pH values of soils which did not receive lime. Application of rock phosphate resulted in a small positive effect on soil pH throughout the 2 cycles of crops.

The effect of treatments on P extractable from the soil is shown in Fig. 2. Lime applied alone resulted in small increases in extractable P during the 1st cycle of crops, a small decrease in 1967 and no effect in 1968. In 1965, the increase in P extractable from the rock-phosphate-treated soil, 115 ppm, was equivalent to 78% of the amount applied, and the increase in P extractable from the soil treated with lime plus rock phosphate, 183 ppm, was equivalent to 124% of the amount applied. The general tendency throughout the 2 cycles of crops for rock phosphate to interact with lime and result in increased amounts of P extractable from the soil was apparently due to differences in fixation and solubility potentials associated with differences in soil pH (Fig. 1).

The P added in the rock phosphate treatments, 296 lb per acre or 148 ppm in the topsoil, amounted to 32% addition of P to the 468 ppm total P in the topsoil prior to treatment. The total P in the topsoil following treatment, 616 ppm, was approximately equal to the average total P in several Mississippi alluvial soils in Louisiana (3). It has been found in Louisiana that about 14 lb of P are removed each year from the soil in millable cane and trash from a crop yielding 30 tons per acre (5), or the amount removed is equivalent to about 7 ppm of topsoil P. With negligible movement of P in soils (4) and only a small amount removed from the soil by cropping, it is clear that addition

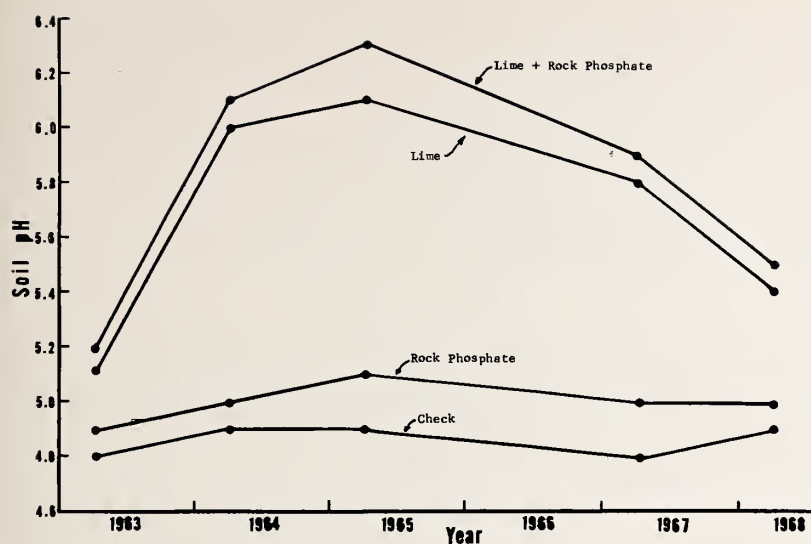


Fig. 1. The effect of agricultural lime and rock phosphate treatments on soil pH.

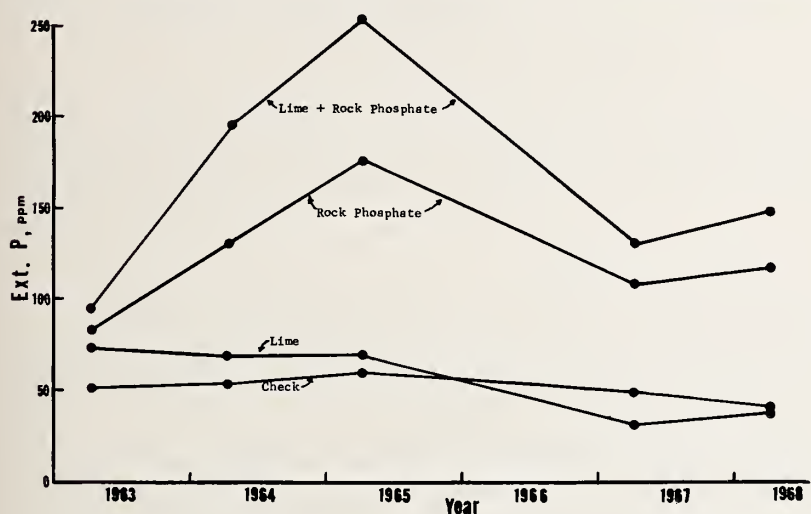


Fig. 2. The effect of agricultural lime and rock phosphate treatments on phosphorus extractable from the soil.



Fig. 3. The effect of agricultural lime and rock phosphate treatments on calcium extractable from the soil.

of 1 ton of rock phosphate will supply P equivalent to the amount removed by several cycles of crops. Whether the amount supplied in rock phosphate may be more economical than smaller amounts supplied in more soluble sources has not been determined in Louisiana.

The amounts of Ca extracted from the soil are shown in Fig. 3. The Ca in rock phosphate was reflected by increases in extractable Ca throughout the period of sampling but the increases were small at the beginning of the first cycle and the end of the second cycle of crops. In 1965, the increase in Ca extractable from the lime-treated soil was equivalent to approximately 58% of the amount applied, and the increase from the soil treated with lime plus rock phosphate was equivalent to approximately 66% of the amount applied. It has been found in Louisiana that about 12 lb of Ca are removed each year from the soil in millable cane and trash from a crop yielding 30 tons per acre (6, 8), or the amount removed is equivalent to about 6 ppm of topsoil Ca.

It was concluded from the data presented and from the work of Davidson (2) that liming acid soils should result in beneficial effects throughout 2 cycles of sugarcane crops of 2 - 3 crops per cycle. It was also concluded that application of finely ground rock phosphate at the rate of 1 ton per acre may be of benefit for several cycles of crops when applied to soils of moderate to strong acidity but may result in little effect on yield when the soil pH is above 6.0.

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THE USE OF PROGRAMMING CALCULATORS IN SUGARCANE BREEDING

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ABSTRACT

Programs were written for a programming calculator for use in the sugarcane breeding project at the US Sugarcane Field Station, Canal Point, Florida. The calculator is coupled with an electric typewriter to provide a printout in a designated format. Data from field plots and crusher juice analyses are processed and printed on predesigned data sheets. Our programs currently include factors for converting from the polariscope reading of the crusher juice to pol (sucrose) in crusher juice, from sucrose in crusher juice to theoretically recoverable lb of sugar per ton of cane, and from estimated lb of cane per plot to estimated tons of cane per acre. Sugar per acre is estimated as the product of sugar per ton and tons of cane per acre. Number of millable stalks per plot is obtained about September 1, prior to severe lodging. During the last week of October, random samples of millable stalks are cut from each plot, transported to Canal Point, and crushed with a 3-roller sample mill. Average stalk weights, crusher juice weights, and brix and pol are recorded on each mill tag. These data along with number of stalks per plot are used in all subsequent calculations.

The sugarcane breeding program at the US Sugarcane Field Station, Canal Point, Florida is conducted in cooperation with the Agricultural Research and Education Center at Belle Glade, and the Florida Sugarcane League, Inc. Between 2,000 and 2,500 samples are normally cut and milled to determine juice quality the last week of October and the 1st week in November. Numerous calculations must be completed by the end of the 2nd week in November to make decisions on which clones to advance for further testing.

SELECTION PROGRAM

The USDA sugarcane breeding program was recently described (3). In brief we grow about 60,000 seedlings per year. Between 4,000 and 5,000 plants from these seedlings are selected at 6 - 9 months of age for advancement to Stage 1. These plots (1-row, 5 ft long) are planted on the station. At about 1 year of age, promising clones are advanced to Stage 2. There are 400 - 600 clones planted on the station (warm land) in 2-row plots 22 ft long and the best 150 - 200 are also planted on cold land in 2-row plots 15 ft long. The planting on the station is evaluated in the plant cane crop only whereas the cold land planting is evaluated in the plant cane and 1st stubble crops. When the Stage 2 planting on the station is about 1 year of age, 50 - 70 clones are selected for advancement to Stage 3. Stage 3 plantings have 2 replications of 2-row plots 15 ft long at each of 7 locations. Locations were selected to represent the various soil types and environmental conditions that exist in the industry. The 15 - 20 of the clones that perform best in the plant cane crop are exchanged with the Agricultural Research and Education Center at Belle Glade. One year later, 6 - 10 clones are advanced to Stage 4, the final testing stage, based on the combined data from plant cane and 1st stubble crops.

RECORDS SYSTEM

We designed a loose leaf record-keeping system which permits organizing the data sheets in the same order as clones are planted in the field. Individual data sheets can be inserted in an electric typewriter driven by a programming calculator. Results of calculations based on field and laboratory data are printed directly on these sheets. A sample data sheet for Stages 1 and 2 is shown in Fig. 1. All printed letters and numbers resulted from programming the calculator and hand written numbers were field notes. Data for each clone advanced to Stage 3 are transferred to individual data sheets (Fig. 2). All data taken in the plant cane crop of Stage 3 are also recorded on these sheets. Another data sheet is used for data collected in 1st stubble of Stage 3. At the time a clone is considered for advancement to Stage 4, all of the data for that clone have been compiled on 2 data sheets. It is necessary to transfer only those data collected in Stage 1 and 2, thereby keeping errors to a minimum.

DATA RECORDED

About September 1, data are recorded on selected clones in Stage 1 for height, erectness, stalk diameter, and stalk number. Stalk weight is obtained from a 12-stalk sample cut for seedcane to plant Stage 2 on the station. Brix and flowering status are obtained in November or early December.

Ratings on germination, height, stooling, and shading are obtained during the last week of April in Stages 2 and 3. Mid-season ratings are made again about July 1 on height, stooling, and shading. Numbers of stalks per plot are counted in late August. A 10-stalk sample is cut the last week in October, weighed to obtain average stalk weight, and milled to obtain crusher juice brix, polariscope reading and weight. Flowering notes are obtained in December.

PRINTING PROGRAMS

For Stages 1 and 2, a program was written for the Wang 720B with 701 outprint writer (Fig. 3), which prints the CP number, location, and stage number. Each data sheet accommodates 6 clones (Fig. 1). A 2nd printing program prints the CP number, location, and stage for data transferred to Stage 3 sheets from Stage 1 and 2 sheets. In addition it prints on these same Stage 3 data sheets the location, replication number and stage number for each of the 7 locations in the plant cane crop. The mean, standard deviation and confidence interval are identified near the bottom of each data sheet. A 3rd program prints on another data sheet the CP number, location and replication for each of the 7 locations in the 1st stubble crop of Stage 3. Again, the mean, standard deviation and confidence interval are identified near the bottom of each data sheet.

CALCULATING PROGRAMS

Three programs were written to calculate the data in Stages 1, 2, and 3. For Stage 1, stalk number, average stalk weight, and brix are keyed into the calculator from the data sheets. The program instructs the Wang 720B to calculate and print yield of cane and brix in tons per acre. These calculations are made after the clones have been chosen for advancement to Stage 2 because the average stalk weight is obtained by weighing the stalks cut for seedcane.

For Stage 2 calculations, stalk number is entered from the data sheet and average stalk weight, brix, and polarization reading are entered from the mill tag that identified the 10-stalk mill sample. Average stalk weight and brix are printed as entered. The polariscope reading is converted to pol (sucrose) % crusher juice and then printed. Prior to making these calculations sugar per ton for the check variety is calculated and entered in the program so that sugar per ton in % of the check as well as in lb is printed. A variety correction factor of 1.00 is assumed at this stage in the selection program (1, 2). Factors are included in the program to convert stalk number, stalk weight and sugar per ton to yield in tons of cane and sugar per acre. Crusher juice extraction is calculated and printed. The program was written to accommodate the different plot sizes at the Stage 2 locations.

The program for Stage 3 utilizes the same basic information as the program for Stage 2 but for each character calculates and prints the mean, standard deviation and the confidence interval for the 14 plots in the plant cane crop. This same program is used to calculate and print the data obtained in the 1st stubble crop of Stage 3.

CONCLUSIONS

High speed programming calculators with a printing capability enable the researcher to more fully evaluate experimental varieties before making decisions to discard or advance them for further testing. Basic data recorded in field and laboratory can be utilized to obtain all derived values of interest. For medium-sized breeding programs, the system described here offers several advantages such as: minimal transcription of data is necessary, data are printed in a legible orderly fashion, and summary statistics are obtained without re-entering the data.

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C. P. NO.	PARENTAGE	LOCATION	REP.	STAGE	EARLY	MID	RECTANGULAR	ST. DIA.	ST. NO.	ST. BT.	BRIX	SUCR.	BRIX OR SUCR. CHECK	IBR. S/T	YIELD CANE PER ACRE	YIELD SUCR. PER ACRE	Z C.J. GEL.	REMARKS
CP71-1001	CP54-552R	Sta.	1															
(49-97)	CP59-15	Sta.	2	10	5	5	5	5	2	18	201	18.0	19.6	16.89	114	234.3	67.1	7.86
		S.G.	2	9	6	5	5	5	6	2	108	18.0	20.2	17.07	114	235.3	48.6	5.71
CP71-1002	CP56-59	Sta.	1															
(67-276)	CP56-59	Sta.	2	10	7	6	5	7	6	5	183	18.6	17.3	14.26	96	193.9	85.4	8.28
		S.G.	2	10	7	6	6	6	5	7	93	18.6	18.4	15.02	98	203.1	48.6	4.93
CP71-1003	CP56-59	Sta.	1															
(67-276)	CP56-59	Sta.	2	9	4	5	4	4	5	4	212	18.2	18.1	15.64	106	218.1	56.3	6.14
		S.G.	2	9	4	5	4	4	5	4	99	18.0	19.3	16.17	108	221.8	40.2	4.46
CP71-1004	CP59-50	Sta.	1															
		Sta.	2	9	4	5	5	4	5	4	208	18.4	22.7	20.42	142	291.4	42.3	6.20
		S.G.	2	9	5	6	4	5	5	4	104	18.4	20.0	18.73	132	272.3	36.2	4.93
CP71-1005	CP56-63	Sta.	1															
		Sta.	2	10	7	6	6	7	6	6	231	18.6	15.5	11.96	76	156.6	86.9	6.80
		S.G.	2	10	7	6	7	7	6	6	115	18.0	16.0	12.03	75	155.1	61.2	6.75
CP71-1006	CP59-132A	Sta.	1															
		Sta.	2	9	5	5	5	5	5	5	202	18.4	18.7	15.38	101	209.0	72.6	7.59
		S.G.	2	10	5	5	5	5	5	5	95	18.0	19.2	15.64	103	212.4	49.6	5.27

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Figure 1. Field and laboratory data sheet showing the format for recording and calculating data in Stages 1 and 2 at Canal Point, Florida

FIELD AND LABORATORY DATA SHEET - SUGARCANE																						
C. P. NO.	PARENTAGE	LOCATION	REP.	STAGE	EARLY			MID			RECTANGULAR	ST. DIA.	ST. NO.	ST. WT.	BRIX	SUCR.	BRIX OR SUCR. CHECK	IBR. S/T	YIELD CANE PER ACRE	YIELD SUCR. PER ACRE	Z. C. J. TKT.	REMARKS
					STOK.	SHAG.	HT.	STOK.	SHAG.	HT.												
CP 68- 1031	CL47-23X	Sta.	1																			
	CP57-614	Sta.	2	10	6	6	5	6	6	5	2	NS	ML	210	34	16.2	13.39	95	178	61.7	5.58	61
CP 68-1032		S.G.	2	9	6	5	5	6	6	5	5	NS	M	112	26	18.4	15.30	99	204	42.3	4.38	60
		Beat.	1	3	6	6	5	5	6	5	6	NS		168	18.0	17.8	14.28	93	191.2	97.5	9.33	60
		Beat.	2	3	10	6	5	5	6	5	6	NS		137	18.1	14.74	96	198.8	89.3	8.88	53	
		Hatt.	1	3	10	5	5	5	5	6	3	NS		153	18.0	18.2	14.59	95	195.4	77.7	7.59	62
		Hatt.	2	3	10	6	6	5	5	5	6	2	NS	102	18.3	17.2	14.51	97	199.7	48.8	4.88	60
		Lvken	1	3																		
		Lvken	2	3																		
		Okee.	1	3	9	6	5	5	6	5	6	1	NS	80	18.3	15.51	104	214.0	37.1	3.97	55	
		Okee.	2	3	9	6	5	5	6	5	6	1	NS	71	18.3	15.92	108	222.7	50.2	5.59	56	
		Saun.	1	3	10	6	5	5	6	5	6	1	NS	149	18.0	15.9	14.10	97	199.1	64.9	6.46	74
		Saun.	2	3	10	6	5	5	6	5	6	1	NS	154	18.0	13.54	86	177.5	84.9	7.54	61	
		S.G.	1	3	10	6	5	5	6	5	6	1	NS	81	18.5	15.29	107	209.4	29.4	3.07	56	
		S.G.	2	3	10	6	5	5	6	5	6	1	NS	96	18.6	15.07	108	222.0	33.7	3.74	55	
		Hedg.	1	3	9	6	5	5	6	5	6	2	NS	138	18.0	17.1	12.22	74	152.3	76.1	5.78	58
		Hedg.	2	3	9	6	5	5	6	5	6	3	NS	118	18.6	16.3	14.07	95	196.1	61.6	6.03	57
		*FAH												120.9	18.4	17.6	14.56	96	198.2	62.6	6.07	59.4
		S.O.												61.29	1.15	1.64	2.02	18.11	37.17	43.91	3.816	10.34
		C.L.												56.30	1.0	1.5	1.96	16.6	34.14	40.34	3.50	9.50

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Figure 2. Field and laboratory data sheet showing the format for recording and calculating data in Stage 3 at Canal Point, Florida.



Figure 3. Programmable calculator with printing capability (Wang 720B and 701 output writer) used in the sugarcane breeding program at Canal Point, Florida.

THE OUT-OF-SEASON FLOWERING OF SUGARCANE
AND ITS SIGNIFICANCE FOR BREEDING

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ABSTRACT

Two out-of-season flower induction experiments, each with 25 varieties, were conducted at Baton Rouge during 1971-72. The 1st experiment was conducted in the greenhouse from October 1, 1971 - January 16, 1972. The 2nd experiment was maintained in the greenhouse from January 16 - April 10, 1972, and then transferred outside where plants were moved into the photoperiod house at night for the next 46 days to obtain the proper photoperiod. The treatment in the 1st experiment consisted of 60 photoinductive cycles for flower initiation followed by 45 non-inductive short days for flower development. In the 2nd experiment, the number of photoinductive cycles was increased to 85. In both experiments each photoinductive cycle contained 10 hr of natural daylight followed by 2 hr 15 min. of supplemental electric light. In the 1st experiment, flowers initiated in 21 varieties but emerged in only 7 varieties. In the 2nd experiment, 22 varieties initiated flowers, and flower development is proceeding normally. These results indicate that flower induction is possible in the winter and that the crossing season can be extended to late spring and perhaps through early summer. This will make possible some interspecific crosses involving our best commercial varieties, which naturally flower in the fall, and some wild species of *Saccharum* and other genera, which flower predominantly in the summer.

INTRODUCTION

Sugarcane flowering induced by photoperiodic adjustments has been established and used in Baton Rouge since 1954 for the purpose of breeding and developing new varieties for the Louisiana sugar industry. Under this system, the photoperiodic induction takes place in the summer, while the actual flowering occurs in the fall, with the peak of flowering in October. Under our conditions this period of the year is the best time to make crosses to get maximum seed set.

The range of the flowering period for the early, medium and late flowering varieties of sugarcane is wide enough to allow crosses between them in all possible combinations. The mid-fall and the early winter induction results in flowering in the spring. This could extend the crossing period through that season of the year. On the other hand, late winter and early spring induction results in flowering in the early summer. The practical aspect of this summer flowering is outstanding for sugarcane breeding, because it will make possible the crossing of our best commercial and breeding varieties with some wild species of *Saccharum* and other genera, which flower predominantly in the summer. This basic crossing was extremely difficult in the early years of breeding of sugarcane in the continental United States and became possible only through interhemispherical shipment of pollen (1).

Apart from the practical significance for sugarcane breeding, the out-of-season flowering of sugarcane raises some questions concerning some controversial points in sugarcane flowering. These questions include: Is the light intensity, the increasing photoperiod or the temperature responsible for the lack of natural flowering in the spring?

Burr et al (2) considered light intensity an important factor required before the induction period. They further considered temperature as responsible for lack of natural flowering of sugarcane in the spring rather than the lack of shortening days. Chilton et al (3) considered the gradual shortening of day length as the responsible factor for flowering of sugarcane. Paliatseas (5) reported that within the inductive range of day length decreasing, increasing and constant photoperiods had the same effect on flowering of sugarcane. He further proved that by adjusting the night temperature, flower initiation occurred in several varieties of sugarcane by spring natural photoperiod (5). Coleman (4) believed light intensity should be high during the 20-day induction of sugarcane flowering required for Hawaii. The low intensity of light prevailing in the spring in Hawaii is responsible, according to him, for the failure of natural flowering in the spring.

MATERIALS AND METHODS

Experiment on the induction of flowering of sugarcane by adjusted photoperiod and temperature in the fall and winter 1971 (October 1, 1971 - January 15, 1972).

The material for this study included 25 varieties of sugarcane, 17 CP, 3 L and 5 foreign varieties. Fifteen were easy flowering (CP 44-101, CP 44-155, CP 52-1, CP 52-15, CP 52-68, CP 57-614, CP 58-48, CP 59-22, CP 61-37, CP 61-39, CP 66-346, CP 70-400, L 61-67, L 62-86, and L 62-96), 4 were medium flowering (CP 57-526, CP 59-43, CP 65-357, and NCo 310) and 2 were reluctant flowering varieties (CP65-350, CP 70-401). Also included were 4 nonflowering varieties (Louisiana Purple, Badila, Otaheite and B51-415). The varieties were grown in the greenhouse in 10 gal galvanized cans or in stovepipe tubes. Growth was not uniform. Some had older stalks treated photoperiodically in the summer but failed to flower. Some others were grown from tillers after the flowering stalks were cut. All the stalks which were available and had 4 exposed joints were marcotted by wrapping 2 joints of each in a black polyethylene bag filled with a wet mixture of soil and peat moss. After 2-3 weeks, roots were formed, and the stalks were cut and planted in new stovepipe tubes filled with a mixture of soil, peat moss and sand. On October 1, 1971, the tubes with the plants were placed in the plastic greenhouse under 2 banks of fluorescent lights controlled by an electric time switch. The time switch was adjusted to put the lights on in the afternoon before sunset and off in the evening after sunset so that the sugarcane plants received 10 hr of natural light and 2 hr 15 min. natural and electric supplemental illumination. The distance of lights from the leaf canopy was about 3 ft.

The day temperature was uncontrolled during most of the time except during some cold days without sunshine, during which thermostatic heating was provided at 75-80 F. The photoperiodic treatment for flower initiation terminated at the end of November 1971.

From the 1st of December 1971 through the 15th of January 1972 a 46-day photoperiodic treatment at 11 hr 40 min. was given for flower elongation. Then the plants were transferred inside the big greenhouse for flower emergence. Examinations for flower initiation were not made but it was assumed to have occurred if the treated stalks showed flower elongation. Some of the elongated flowers were emerged, but the majority of them aborted under greenhouse conditions. Data on elongation, emergence and abortion were taken during January, February, and March.

Experiment on the induction of flowering of sugarcane by adjusted photoperiod and temperature treatments in the winter and spring 1972 (January 15 - May 25, 1972).

The material for this study again included 25 varieties of sugarcane, 16 CP, 7 L and 2 foreign varieties. Seventeen were easy flowering (CP 48-103, CP 52-1, CP 52-15, CP 52-68, CP 58-48, CP 59-22, CP 61-37, CP 63-309, CP 66-391, CP 70-402, CP 70-403, L 60-25, L 61-52, L 61-67, L 62-86, L 62-96, and L 65-69), 2 were medium flowering (CP59-43 and CP 65-357), 4 were reluctant flowering (CP 65-350, CP 66-376, L 64-67 and Co 290) and 2 were non flowering varieties (Otaheite and Louisiana Purple). The sugarcane plants were mostly tillers grown in stovepipe tubes after the flowering stalks were cut. Due to higher temperature in the greenhouse and lower intensity of light, the plants had a fast competitive growth with long internodes. The best of these were marcotted at the end of December 1971 by wrapping 2 joints of each in a black polyethylene bag filled with wet soil mixture, as described previously. After roots were formed, the stalks were cut under the rooted portion of the stalk and planted in new tubes filled with a mixture of soil, peat moss and sand. On January 16, 1972, the tubes with the plants were transferred from the big greenhouse to the plastic greenhouse under an electric light system consisting of 2 rows of fluorescent twin light banks. The light banks were adjusted at a distance of about 3 ft from the leaf canopy of the sugarcane. The photoperiodic treatments included 10 hr of natural light and 2 hr and 15 min of supplemental illumination from January 16-March 15, 1972. From March 16 - April 9, 1972, the plants received only natural photoperiod. From April 10 - May 25, the plants were taken out of the greenhouse and placed on cars which rolled in and out of 2 photoperiod houses according to a carefully prepared schedule so that the plants received 11 hr 40 min photoperiodic treatment. Data on flower initiation, elongation and emergence were taken during April and May 1972. The night temperature inside the greenhouse was kept at 72-76 F. The night temperature inside the photoperiod houses was uncontrolled.

EXPERIMENTAL RESULTS

Experiment on the induction of flowering of sugarcane by adjusted photoperiod and temperature in the fall and winter 1971-1972 (October 1, 1971-January 15, 1972).

The results on flower initiation, elongation and flower emergence of the 25 varieties of sugarcane treated by inductive photoperiod in the fall and winter of 1971-72 are shown in Table 1. Twenty-one varieties of sugarcane initiated and elongated flowers, including 15 easy flowering, 4 medium flowering, and 2 reluctant flowering varieties. Of these only 7 varieties had flowers emerge, including 5 easy flowering, 1 medium flowering and 1 reluctant flowering variety. The percent of variety flower emergence was 33.

Table 1. Number of sugarcane varieties induced to flower initiation, elongation and emergence by controlled photoperiod and temperature treatments from October 1, 1971 - January 15, 1972.

Flowering classification of varieties	No. varieties treated	No. of varieties induced to flower			% variety emergence
		Initiation	Elongation	Emergence	
Easy	15	15	15	5	33.3
Medium	4	4	4	1	25.0
Reluctant	2	2	2	1	50.0
Nonflowering	4	0	0	0	0.0

Table 2 shows the list of sugarcane varieties that emerged flowers. There was a difference in flower emergence between varieties. Flower emergence varied from 33 - 75%, with the average of all emerged stalks being 52%. Fourteen of the treated varieties that had flower initiation and flower elongation failed to have their flowers emerge. Table 3 lists these varieties and includes 11 easy flowering and 3 medium flowering varieties.

Table 2. List of sugarcane varieties which initiated and emerged flowers by controlled photoperiod and temperature.

Varieties	Treated	No. of plants		% flower emergence
		Initiated flowers	Emerged flowers	
CP 52-15	3	3	1	33.3
CP 57-526	3	3	2	66.6
CP 58-48	4	4	3	75.0
CP 61-37	4	4	2	50.0
CP 65-350	3	2	1	50.0
CP 70-401	3	2	1	50.0
L 62-86	4	3	2	66.6

Table 3. List of sugarcane varieties which initiated but failed to emerge flowers, following controlled photoperiod and temperature treatments from October 1, 1971 - January 15, 1972.

Varieties	Flowering classification	Treated	No. of plants	
			Initiated flowers	Aborted flowers
CP 44-101	Easy	3	3	3
CP 44-155	"	2	2	2
CP 52-1	"	2	2	2
CP 52-68	"	3	3	3
CP 59-22	"	2	2	2
CP 59-43	Medium	3	2	2
CP 61-39	"	3	3	3
CP 57-614	Easy	3	3	3
CP 65-357	"	4	3	3
CP 66-346	"	3	3	3
CP 70-400	"	3	3	3
L 61-67	"	4	4	4
L 62-96	"	3	3	3
NCo 310	Medium	4	3	3

Experiment on the induction of flowering of sugarcane by adjusted photoperiod and temperature treatment in the winter and spring of 1971-72 (January 16 - May 25, 1972).

The results of this experiment are shown in Table 4. Twenty-two varieties initiated and elongated flowers, but only 8 had flowers emerge. Of the 22 sugarcane varieties that showed flower initiation, 17 were easy flowering varieties, 2 medium flowering and 3 reluctant flowering varieties. Of the 8 varieties that had flowers emerge, 7 were easy flowering and 1 was reluctant flowering.

Table 4. Number of sugarcane varieties induced to flower initiation and flower emergence by controlled photoperiod and night temperature treatments from January 15, 1972 - May 25, 1972.

Flowering classification of varieties	No. varieties treated	No. of varieties induced to flower			% variety emergence
		Initiation	Elongation	Emergence	
Easy	17	17	17	7	41.2
Medium	3	2	2	-	-
Reluctant	4	3	3	1	33.3
Nonflowering	1	0	0	0	0.0

The varieties that initiated, elongated and emerged flowers and the dates of the 1st emergence for each of these varieties are shown in Table 5. Seven of these varieties were easy flowering and 1 was reluctant flowering. The dates of the 1st flower emergence are spread from April 28 - May 24, 1972. Table 6 shows the list of the varieties which initiated flowers and showed advanced signs of elongation upon the termination of the treatment May 25, 1972. Fourteen varieties of sugarcane are in this list, including 10 easy flowering varieties, 2 medium flowering, and 2 reluctant flowering varieties. This table also shows that half of the 14 varieties had some stalks with flower elongation and some others grown vegetatively. Out of 40 stalks treated, 28 showed flower elongation and 12 were grown vegetatively. There has been no sign of flower abortion so far.

Table 5. List of sugarcane varieties which initiated elongated and emerged flowers by controlled photoperiod and temperature treatments from January 15 - May 25, 1972.

Varieties	Flowering classification	No. sugarcane plants			Date of first Emergence
		Treated	Initiated	Emerged	
CP 52-15	Easy	1	1	1	5-20-72
CP 52-68	Easy	2	2	1	5-24-72
CP 58-48	Easy	2	2	1	5-28-72
CP 61-37	Easy	5	5	3	5-19-72
CP 70-402	Easy	3	3	2	5-15-72
CP 70-403	Easy	2	2	1	5-21-72
L 60-25	Easy	2	2	2	5-16-72
L 64-67	Reluctant	1	1	1	5-22-72

Table 6. List of sugarcane varieties which initiated flowers and showed advanced signs of elongation following adjusted photoperiod and temperature treatments from January 16 - May 25, 1972.

Variety	Flowering classification	No. plants treated	No. of plants showing		
			Initiated	Advanced elongation	Vegetative growth
CP 98-103	Easy	4	3	3	1
CP 52-1	Easy	2	2	2	0
CP 59-22	Easy	2	2	2	0
CP 59-43	Medium	3	2	2	1
CP 63-309	Easy	2	2	2	0
CP 65-350	Reluctant	4	2	2	2
CP 65-357	Medium	4	2	2	2
CP 65-391	Easy	2	1	1	1
L 61-52	Easy	1	1	1	0
L 61-86	Easy	3	3	3	0
L 62-86	Easy	1	1	1	0
L 62-96	Easy	2	2	2	0
L 65-69	Easy	4	3	3	1
Co 290	Reluctant	6	2	2	4

DISCUSSION

The induced flowering of sugarcane is operated in the summer, every year, and for its completion a minimum of about 120-150 days photoperiodic treatment is required. The 1st stage of flowering, flower initiation, requires a minimum of 40-45 days for the easy flowering varieties and about 60 days for the reluctant flowering ones. If conditions prevailing after flower initiation are favorable (shorter days and normal temperature), flowering of sugarcane could be completed in a shorter period than the 150 days mentioned. With that in mind, the first out-of-season induction of flowering experiment was planned. A 60 day induction for flower initiation was followed by 45 short days for flower elongation and emergence. The extensive flower initiation of a large number of sugarcane varieties indicates that the noninductive natural photoperiod (11 hr and 53 min - 10 hr 21 min), could become inductive by supplemental illumination. Also the lower intensity of light prevailing in October and November (5000-7000 fc) is sufficient for flower initiation. The failure of flower emergence or abortion that was exhibited by the majority of the sugarcane varieties indicates that some other factors, beside short days and normal temperature, are not met.

The most plausible greenhouse condition which I would suggest as responsible for flower abortion is the fast elongation created by intercompetition of stalks for light. Probably the rate of elongation of the joints and the leaf-sheaths is not the same with the rate of elongation of the inside of the leaf-sheath embryonic flower. An entanglement of the embryonic spikelets within the leaf-sheath of the last leaf probably stops the growth of the flower and causes its death.

The results of the 2nd experiment also indicate that flower initiation of sugarcane, under greenhouse conditions, is possible by winter and spring natural photoperiod, supplemental electric illumination and adjustment of night temperature at 72-76 F. A higher intensity of light than that prevailing in the spring is not a requirement for flower initiation. The normal flower elongation, flower emergence and the lack of flower abortion indicates that outside conditions are more favorable for flower development than similar conditions in the greenhouse.

The dates of flower emergence of the already flowered varieties (end of May) and the normal progress of flower elongation of the nonflowered ones indicate that most of them probably will flower in June and July. This will make possible basic interspecific and intergeneric crossing of sugarcane, which under our conditions is extremely difficult, and has been possible only through interhemispheric shipment of pollen.

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SELECTING COMMERCIAL SUGARCANE VARIETIES FROM LARGE SEEDLING AND CLONAL POPULATIONS

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ABSTRACT

Selection procedures and techniques used to isolate potential commercial sugarcane varieties from populations of up to 250,000 seedlings or experimental varieties are described. The discussion is limited to the pre-replicated yield stages of test, i.e., parent selection, seedling selection in the greenhouse and single stool nursery, selection in 1st and 2nd clonal line trials, and selection in unweighed, replicated line tests. Emphasis is placed on how the material is handled at each test stage and what selection criteria are stressed at each stage, as opposed to why specific procedures are followed. It is not suggested that this or any selection program would be efficient for every set of conditions or where major breeding objectives differ. However, many of the techniques evolved in the selection program at the Houma Station would be adaptable to any other area.

INTRODUCTION

Each year over a million sugarcane seed are produced at Canal Point, Florida (CP varieties) and Baton Rouge, Louisiana (L varieties) (10, 5). The system for selection, testing, and releasing new sugarcane varieties in Louisiana is outlined in a 3-way cooperative agreement of the American Sugarcane League, The Louisiana Agricultural Experiment Station, and the USDA. The cooperative agreement, as implemented by the 3 agencies, has served the industry well since 1926 and provided it with locally adapted, high yielding, CP and L varieties to meet its changing needs.

This paper outlines the system, techniques, and procedures used in Louisiana to select potential commercial varieties from very large initial seedling populations. Considerations are limited to a brief outline of the entire test system followed by a more detailed discussion of the initial testing in the program. The paper is also limited to the breeding effort directed toward the immediate selection of a commercial sugarcane variety. The evaluation of new germ plasm and the development of new lines for Louisiana, an equally important phase of the total breeding effort, are discussed elsewhere by Duncelman and Breaux (6).

TIMETABLE FOR VARIETY RELEASE

New seed produced at Canal Point, Florida during the past crossing season (1971-72) will advance through the variety test program (Table 1) toward a possible variety release about 12 years hence, in 1984. Over 200,000 seedlings from this series have already been screened in the greenhouse at Houma for resistance to sugarcane mosaic and the 77,915 seedlings that escaped infection were established as single stools in the field in April, 1972.

Table 1. Stages of testing in the variety program in Louisiana/

Year Grown	Test Stage	Approx. no. of Seedl. or Clones
1971-72	: Crosses made and seed germinated in greenhouse	250,000
1972	: Seedlings established in field in April	60,000
2 1973	: Selection of surviving 1st stubble seedlings	53,000
	: Planting 1st line trials	
3 1974	: Selection in 1st line trials	4 to 7,000
	: Planting 2nd line trials	
4 1975	: Evaluation in 2nd line trials plant cane	1,500
1976	: Evaluation in 2nd line trials stubble cane	1,500
5	: Selection and assignment of CP numbers	
	: Planting replicated nurseries	
1977	: Selection in plant cane nursery	100
	: Exchange of selected varieties with L.S.U.	
	: Planting 1st infield replicated test	
	: (2 reps.) of CP varieties only	

Table 1. (Continued)

Year Grown	Test Stage	Approx. no. of Seedl. or Clones
1978	: Infield testing	40
	: a) obtain plant cane data from 1st infield test	
	: b) planting 2nd infield test (3 reps.) CP and L varieties	
1979	: Infield testing	40
	: a) obtain 1st stubble data from 1st infield test	
	: b) obtain plant cane data from 2nd infield test	
	: c) plant a 3rd infield test CP and L varieties	
	: d) plant outfield introductions at 14 locations and Primary Increase Stations at 3 locations	
1980	: Outfield testing and increase	12
	: a) outfield test planted (4 reps.) Varieties included based on infield P. C. data, 1st stubble data and 2nd stubble observations	
	: b) increase on Primary Stations	
1981	: Outfield testing and increase	8
	: a) obtain outfield plant cane data	
	: b) introduce to 44 Secondary Stations	
1982	: Outfield testing and increase	2
	: a) obtain outfield 1st stubble cane data	
	: b) increase on Secondary Stations	
1983	: Outfield testing and increase	1
	: a) obtain outfield 2nd stubble data	
	: b) increase on Secondary Stations	
1984	: Release to the sugar industry	1

1/ Seedlings produced in 1971-72 at Canal Point, Florida are used as an example.

The initial field selection of the plants in single stools will not be practiced until the Fall of 1973 in the 1st stubble crop. At this time, the first clonal planting of 4,000 - 7,000 experimental varieties will be made to single-row plots, 6-ft in length (Table 1).

In 1974 the 6-ft plant cane plots will be re-selected and should yield about 1,000 experimental varieties for planting in the 2nd line trial, a 15-ft single-row clonal plot. The 2nd line trials will be rated and sampled in plant cane in 1974 and in 1st stubble in 1976. All available data from the clonal trials will be summarized and used to select approximately 100 experimental varieties to receive permanent CP variety numbers (Table 1).

The approximately 100 CP assignments from this crossing series will receive CP '76 numbers, from CP 76-300 to CP 76-400, etc. Note that the first 2 digits of a CP number are a year designation that denotes the year the permanent variety number is assigned. It is not the year the cross is made. To arrive at the crossing year, 5 years must be subtracted from the CP assignment year. CP variety designations begin with the number 300 to avoid duplication with L varieties assigned numbers the same year. Louisiana varieties begin with 1. Variety designations at Canal Point begin with 100 to avoid duplication with the Louisiana CP and L assignments.

The 100 new 1976 varieties will be planted to a 2-replicate nursery trial (6- x 20-ft plots) at the Houma Station where further yield estimates are made, and the varieties will be further reduced to about 40 in 1977 (Table 1). Also, a separate increase plot is established for each variety, which divides the program at this point into a separate test phase and seed increase phase. The increase plots provide seed cane for infield variety trials and for establishing a heat treated seed increase to later supply the outfield tests and the primary increase stations.

Matherne (12) described the infield test program in detail. The approximately 40 varieties included in the first 2-replicate infield variety trial in 1978 will all be CP varieties (Table 1). However, in the larger 3-replicate trial grown in 1979, about half the varieties tested will be L varieties, the products of the crossing and selection program at the Louisiana Agricultural Experiment Station. The same CP and L varieties are included in these separate infield test programs at Baton Rouge and Houma. From this point on in the program, the 3 agencies meet before each planting season and jointly decide what varieties to discard. Approximately 12 of the '76 varieties (CP and L) will survive the infield tests and be introduced in 1980 to the outfield tests and primary increase stations (Table 1).

Fanguy and Giamalva (7) described the operations of the outfield tests in Louisiana. Outfield tests are planted at 13 locations on the farms of cooperating growers strategically located throughout the sugar industry. A USDA agronomist supervises 7 of these test field locations and an LSU agronomist supervises 6 of these locations.

A 1976 CP or L variety can be formally considered for release only after plant cane, 1st and 2nd stubble yield data on light and heavy soils at the different outfield test locations are collected, combined, and analyzed. For the 1976 CP varieties these yield data would be obtained in the outfield tests in the 1981-83 crops (Table 1).

In the summer of the release year, 1984, the variety subcommittee composed of representatives of the USDA, Louisiana Agricultural Experiment Station, Louisiana Cooperative Extension Service, and the American Sugarcane League, will meet and after a careful review of the data might decide to release a 1976 CP or L variety. A release statement is drafted to describe the new variety. Included in the description are its productivity and adaptability to the different regions and soil types, resistance to disease and insects, cold tolerance, and its harvesting and milling characteristics.

When ready for release, seed cane of the new variety is increased by grower members of the American Sugarcane League. League agronomists regularly inspect the seed cane plots for variety purity, freedom from disease, etc., at the 3 primary increase stations. In 1982 they will have arranged and supervised the distribution of seed cane to 41 secondary increase stations. Lauden (11) recently described the seed increase program and the agreements entered into by the League and its secondary station operators. The seed increase program has functioned very well in Louisiana to insure a prompt and equitable distribution of seed cane of new varieties from the breeding program. The American Sugarcane League will arrange the purchase and distribution of seed cane of the new 76 CP or L variety from the secondary station operators to individual growers who apply for seed cane. Demand for a new sugarcane variety usually exceeds supply so cane growers that apply are allowed a pro-rata share of the total amount of seed cane based on their cane acreage. Small growers who do not wish to purchase cane, may obtain, at no charge, 10 stalks of the new variety from the Agricultural Extension Agent in their parish.

The minimum 12-year test period required under the Louisiana system is 2 - 3 years longer than some other breeding programs. Concern about this long test system is often expressed by growers and scientists alike. Growing the original seedling crop and the 2nd line trial to 1st stubble before selection, and collecting 2nd stubble data in outfield tests before variety release, lengthens the minimum test period by 3 years. However, most agronomists feel that the precision gained in the early evaluation of stubbling ability is worth the additional time. Each year a new series of varieties is advanced to each test stage so there are new candidates for release every year in spite of the long test cycle. Furthermore, the system is flexible and can be shortened to reduce the generation interval between cycles of recurrent selection. For instance, to utilize the superior mosaic resistance of L 65-69, some of its progeny in single stools and 2nd line trials were selected in plant cane. Very likely, some CP 1973 numbers will be progeny of L 65-69, so it has been cycled in the breeding program in less than 8 years. In this way the primary disadvantage of a long test system, i.e. a long generation interval, is minimized.

THE SEEDLING AND INDIVIDUAL PLANT PROGRAM

New sugarcane varieties significantly better than existing commercial varieties occur at very low frequencies in most sugarcane progenies, even progenies from carefully chosen parents. Their frequency must be increased through selection in the seedling program, so that some are included even among the few new experimental varieties (about 40 each year) planted in infield trials. Moreover, the few really superior varieties are not conspicuous or easy to identify in large individual plant and clonal populations.

Obviously, the breeder cannot observe enough material of each individual plant or clone to accurately measure its yielding ability or commercial potential in the early test stages. Instead, he must select, sometimes more subjectively than he would like, for important and more heritable components of yield or correlated characters of economic importance. He quickly discards most of the individual plants and clones because they fail to meet minimum standards set up for these characteristics. Owing to the effects of the environment on the limited amount of material he observes, the selector inevitably discards some varieties of commercial value and likewise selects many that later prove to be of little commercial value. However, the frequency of superior clones presumably increases at each step in the program. Selection techniques and procedure, selection criteria, and selection intensity used in the seedling program at Houma are detailed below.

Selection Techniques and Procedures. The true seed, or "fuzz", arrives at Houma from Canal Point beginning the first week of January. Before being shipped from Canal Point, a randomly chosen 2 g sample is planted from each cross as a germination test to estimate the number of viable seed per g of fuzz. The fuzz is distributed to obtain a uniform stand of about 500 seedlings per 15" x 24" metal flat.

The flat mixture used to grow sugarcane seedlings is carefully made up of 6-1/2 parts light field soil (silt loam), 1 part sand, and 2-1/2 parts milled sphagnum moss. The soil and sand are screened through a 1/2" mesh hardware cloth, mixed with the milled sphagnum moss, and the mixture is sterilized in bulk in live steam for 2-1/2 hr (Fig. 1). Each flat is cleaned, coated with an asphalt-varnish and filled to within 1/2" of the top. The flats are placed on the greenhouse bench, carefully leveled and thoroughly wet. The seed are then distributed uniformly on the wet level surface, and they are immediately re-wet. The seed are very lightly covered with a finely screened portion of the sterilized flat mixture and wet a third and final time.



Fig. 1. Steam sterilizer used to sterilize soil for flats of sugarcane seedlings.

The seedling flats are covered with a translucent plastic cover (.025" thick). Greenhouse temperature is maintained constantly at 85 - 90 F for at least 3 days after planting. The flats remain covered the first 3 days (except in bright sunlight), when germination is almost complete, and the covers are permanently removed.

About a week later, and every 7 - 10 days thereafter, the seedlings are fertilized, and fungicides are applied to prevent damping off and other seedling diseases. A Dexon (p-Dimethylaminobenzenediazo sodium sulfonate)-Terrachlor (Pentachloronitrobenzene) mixture (35% active each ingredient), is used in the seedling flats. Each flat is drenched with 250 ml of a 200 ppm solution of the fungicide mixture. One teaspoon of a high analysis fertilizer (13-26-13) is added to each gal of the fungicidal solution. The seedlings are also sprayed with Systox 0,0-Diethyl 0 (and S)-2-(ethylthio) ethyl phosphorothioate, 1 teaspoon per gal, at weekly intervals to control mites and red spider. It is desirable to apply fertilizer, fungicides, and insecticides before symptoms of nutrient deficiency, disease, or insect injury occurs.

In about a month the seedlings are large enough to transplant to 2-1/2" round peat pots. Pulverized and sterilized light field soil is satisfactory for growing sugarcane seedlings in pots. The pots are filled with soil, and the young seedlings are individually transplanted into the dry soil by workmen seated at a specially designed potting bench. Three seedlings are usually planted in each 2-1/2" peat pot.

The pots are placed on 2 in. of fresh, level sand on the greenhouse bench and are immediately saturated with water. Seedlings are less difficult to care for in pots than in flats. There are usually no major disease or insect problems. The seedlings are fertilized weekly with ammonium nitrate at a rate of 1 teaspoon per gal of water with a Foliarator. An automatic spray mist system waters the seedling greenhouses. Clipping the tops off the seedlings every 7 - 10 days facilitates watering and produces strong more uniform seedlings for transplanting to the field.

Techniques used to screen the large seedling populations for resistance to sugarcane mosaic were described by Breaux and Tippet (2). The virus is extracted from diseased tissue of POJ 234, mixed with an abrasive and sprayed at high pressure (Fig. 2) on the sugarcane seedlings as soon as they have recovered from the shock of transplanting and are growing vigorously. Symptoms of the disease begin to appear in the seedlings in about 10 days and continue to appear for a month or more after inoculation. The seedling progenies are rogued of all visibly mosaic infected seedlings before transplanting to the field (Fig. 3). After roguing for mosaic most of the pots contain only a single seedling. Pots with 2 seedlings are split in half with a sharp knife and each seedling in the pot is set separately to the field. Seedlings are transplanted during the last 2 weeks of April.

The Holland peat pot transplanter has greatly simplified the transplanting of seedlings to the field. Anzalone (1) reported its use in Louisiana. The 2-row machine used at Houma transplants over 15,000 seedlings per day (Fig. 4).



Fig. 2. Air blast inoculation of sugarcane seedlings with mosaic virus.



Fig. 3. Roguing mosaic infected seedlings before transplanting to the field.



Fig. 4. Transplanting sugarcane seedlings to the field with the Holland transplanter.

Simazine 2-Chloro-4,6-bis(ethylamino)-s-triazine is sprayed at a rate of 1 lb per acre on the seedling drill (36" band) as a preemergence herbicide to control summer annual weeds until the seedlings are rooted and can be cultivated mechanically. The seedlings are irrigated immediately after applying Simazine. About an acre-inch of water is applied with an overhead sprinkler-type irrigation system. If warm weather prevails immediately after transplanting, the seedlings root very quickly and grow so rapidly that hand hoeing is minimized.

Once established, the seedlings are handled like a commercial sugarcane crop. In fact, 1st year plants from seedlings regularly yield about 30 tons of cane per acre at Houma.

The 1st year plants from the seedlings are cut with a sugarcane harvester in late December or early January. Survival and mosaic counts are made in the 1st stubble crop the next spring. In May, mosaic infected plants that escaped detection in the greenhouse or contracted the disease from natural field spread are chemically rogued with Baron 2-(2,4,5-Trichlorophenoxy)ethyl 2,2-dichloropropionate.

Final selection of the individual plants in 1st stubble is made during September. Two stalks are cut from each selected stool, stripped of leaves, bound together with rubber bands and removed from the field to the headland. Two-stalk samples are simultaneously cut from commercial check varieties randomized throughout the seedling nursery. A Hawaiian type punch is used to extract and accumulate a small juice sample from the middle internode of each of the 2-stalk samples. A hand refractometer brix is read and compared to the brix of the commercial check varieties. Plants that meet the minimum brix standard are bundled and identified by cross number; the remainder are discarded. The 2 stalks of each selected plant serve as the seed source for planting the 1st line trial.

No strong positive relationships have been shown to exist between seedling vigor or appearance in the greenhouse and the productive capacity of a sugarcane variety in the field. Therefore, selection for agronomic type is delayed until the initial seedling populations are grown in the field.

However, selection for mosaic resistance is practiced in the greenhouse at Houma. Not all sugarcane breeders and pathologists agree on the effectiveness or desirability of screening seedlings for mosaic resistance. Three conditions, some of which are peculiar to Louisiana, prompt us to attempt to screen for resistance to mosaic even this early in the program. First, mosaic resistance is an urgent breeding objective as the disease is epidemic in commercial fields in Louisiana. It is unlikely that greenhouse epiphytotics or selection pressures will be much more severe than a new sugarcane variety soon meets in the field. Second, recent experience and practical results from the selection program and basic research data both indicate that the frequency of mosaic resistant varieties is higher from screened than from unscreened seedling progenies. Third, the seedling supply consistently exceeds our capacity to test in the field. A full complement of seedlings is brought to the field each year regardless of the selection pressure applied for mosaic resistance in the greenhouse.

The first selection for agronomic suitability is practiced in the 1st stubble single-stool nursery. Recognizing the low heritability for most of the selection criteria at this stage, selection of single stools for agronomic worth has become less rigid in recent years. Although the single stool is still compared as a whole to commercial standards, the following individual characteristics of the single stool are given separate consideration.

- 1) Stalk number is the most important component of tons of cane per acre but, unfortunately, one of the least heritable yield components. Therefore, a liberal selection for stalk number is practiced. Stools with as few as 3 or 4 stalks are selected.
- 2) Stalk diameter is the most highly heritable of single stool selection criteria, but is not strongly, positively, correlated with cane yield. There is a negative association between stalk diameter and stalk number; a medium stalk diameter is sought. Care is exercised not to select rigidly for very large diameter; however, small diameter plants are ruthlessly culled.
- 3) Stalk height is somewhat more reliable than stalk number in single stools, but is less heritable than stalk diameter. There is a negative association between stalk height and erectness. Short, low vigor single stools are discarded, but very tall ones, particularly those that lodge badly, are also rejected.
- 4) Stalk density is promoted by using 2 or more stalks of each stool that meet minimum standards for the above characteristics. These are cross-sectioned and examined. Small holes or scattered pith are acceptable, but stalks containing continuous pith areas are rejected.
- 5) Brix selection was described above. Brix is highly correlated with sucrose and positively correlated with yield of sugar per ton of cane and sugar per acre. Heritability for brix in single stools is higher than for stalk number but not as high as for stalk diameter. The mean brix of CP 48-103 at the time of selection is generally used as the minimum selection standard in single stools.
- 6) Heritability of erectness and brittleness in single stools is low. When single-stool nurseries are mostly erect, (if they have not been completely lodged by excessive wind or rain) canes that are badly lodged or open are rejected in single stools. When nurseries are badly lodged, they are extremely difficult to select. Under these conditions, selection for lodging must be liberal. However, stools that have exposed roots or stools with broken tops are rejected.
- 7) Other criteria are used. Some single stools are rejected for extreme growth cracking, germinated or protruding buds, excess adventitious root formation up the stalk, extreme sensitivity to herbicides, extreme reaction to the sugarcane borer, etc. However, the components of yield are the primary selection criteria.

About 70% of the 250,000 seedlings potted each year take mosaic in the greenhouse and are discarded. About 60,000 - 75,000 seedlings are transplanted to the field and 15% of the resulting single stools fail to stubble. About 15,000 - 20,000 single stools are actually brixed. About 75% of the single stools that mature in the stubble crop are rejected for the agronomic characteristics mentioned above. Normally, about one-half of these meet the minimum brix standard and about 7,000 - 8,000 plants are finally selected from the single-stool nursery and planted to clonal line trials.

CLONAL SELECTION

Varieties are propagated vegetatively and managed like the commercial crop through the line trial stages. The 1st line trials (6-ft plots) are grown at the Georgia Division of the South Coast Corporation at Mathews, Louisiana. The cooperation given by the South Coast Corporation greatly relieves the pressure for land and labor at the Houma Station. The 2nd line trial (15-ft plots) and replicated nursery (2 plots x 20 ft) are grown at the Houma Station.

Selection of varieties with commercial potential is more effective in clonal trials than in seedlings. Objective yield estimates replace subjective ones in the 2nd line trial and replicated nurseries.

Procedure. Varieties in 1st line trials are identified by cross only. The fields are planted and mapped to permit removal of all stakes so they can be harvested mechanically. Commercial check varieties are CP 48-103, CP 52-68, L 60-25, and CP 61-37.

In the spring, mosaic-infected plots are destroyed by roguing with a shovel. No further selection is practiced until late October, when a very liberal visual selection for agronomic type is made, and a red ribbon is attached to each plot to be sampled for juice quality. A minimum brix standard is established from the brix level of the commercial varieties. Three-man brixing crews are organized. Two of the 3 men extract the juice sample by accumulating the juice from punching 5 stalks in each plot. The third crew member reads the refractometer. The red flag is removed if the variety does meet brix standards and the clone is dropped.

Each selected clone is now given a temporary breeding series number, a stalk count is made and the variety is described and visually rated as to its relative overall desirability. A 5-stalk sample is cut for laboratory brix and sucrose analyses and to obtain an estimated stalk weight. A 4-stalk sample is cut for seed, and the 2nd line trials are established.

Commercial check varieties, as used in 1st line trials, are planted every 10th plot in the 2nd line trial nursery. Clones are rated in both the plant and 1st stubble crop of the 2nd line trial. Stand counts and ratings are made in early spring and again in mid-summer. In the fall a mature-stalk count is made.

Ten-stalk samples are harvested when the crop is relatively mature, weighed, and ground for laboratory juice analysis. Estimated plot weight is obtained by multiplying stalk weight by stalk number. Pounds of sugar per ton of cane and sugar per acre are calculated in the normal manner assuming a constant variety correction factor of 1.00.

Just before CP assignment, all the data for each clone are quickly analyzed and summarized on the Wang 700-A computer. The final selection of CP numbers is based on the average estimated yield of the varieties in all the clonal stages. The plots are cut for seed to plant the replicated nursery and to increase each new CP assignment.

The replicated nursery is a randomized complete block design with 2 replications. Estimated yields are calculated as described above, and for the first time a statistical analysis of the yield data is possible. Of course, the desired statistical precision for measuring yield is not yet reached in the small nursery tests. Varieties selected from the nursery enter the infield tests for more precise yield determinations.

Primary selection criteria.

- 1) Yield of sugar per acre. The most successful commercial variety is one that produces the highest yield of sugar per acre. Visual and calculated estimates of yield become the primary basis for selection in clonal line trials. Clones are first rated visually for yield of cane per acre and assigned a commercial grade from 1-10. Breaux (4) described how these visual estimates are used to eliminate obviously inferior varieties. Calculated yield estimates obtained as described above form the basis for final selection of clones in clonal trial.
- 2) Erectness. Breaux (3) also discussed in detail the relationship between erectness in clonal trials and replicated tests. Clones that lodge badly under normal conditions are rejected. However, when clonal trials are severely and generally lodged by hurricane or severe rain-storm, selection for erectness is based more upon the clone's ability to recover from the effects of lodging and its freedom from brittleness.
- 3) Mosaic resistance. Greenhouse screening of seedlings does not screen out all mosaic susceptible varieties. Ten plants are grown from single-eye pieces of each CP candidate, and a greenhouse clonal test for mosaic resistance is conducted. Clones significantly more susceptible than CP 48-103 are discarded.
- 4) Fiber and millability. Milling qualities of sugarcane clones are not investigated until they are introduced to outfield tests and primary stations. The increased selection pressure for high sucrose (high sucrose and high fiber have been reported to be positively associated) and the increased use of interspecific hybrids from the *S. spontaneum* backcross program will probably increase the frequency of high-fiber clones entering variety tests. Hopefully, it will soon be possible to obtain estimates of fiber or millability during the early clonal test stages employing some rapid method like that suggested by Henderson et al (8).
- 5) Borer resistance. CP candidates are established in a separate borer nursery, in cooperation with Houma Station entomologists, where no insecticides are used and high borer populations are maintained (9). Extremely susceptible clones are eliminated, and resistant ones are quickly identified and returned to the crossing program.
- 6) Other criteria. Pathologists initiate tests to evaluate new CP varieties for red rot resistance and establish field spread trials for mosaic resistance in the field. Physiologists also begin to consider cold tolerance and resistance to inversion.

Selection intensity. Clonal selection in the program reduces the number of clones from 7,000 - 8,000 to about 40 that are finally included in infield variety trials.

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INCREASING FREQUENCY OF HIGH SUCROSE CP VARIETIES

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ABSTRACT

Raising the sucrose standard in a breeding program might be expected to decrease the frequency of varieties that exceed this standard. This did not happen. In a 20-year study, yields of sugar per ton of cane were determined for 550 CP varieties tested in the plant cane crop of the replicated yield trials at the Houma Sugarcane Field Station. Since there was considerable fluctuation in sucrose from year-to-year, varieties were grouped by 5-year test periods and average sugar yield determined for each group. In this way performance of the 4 groups could be compared with each other and with the standard varieties. From 1952-1966, CP 44-101 was the standard variety that experimental clones had to equal or exceed for inclusion in the testing program. From 1967-1971 the much higher sucrose variety CP 48-103 was adopted as the standard. However, the average sugar yield in this group (1967-1971) increased from a previous high of 181 to 212 lb per ton. There were as many clones in the program with sucrose above 212 lb per ton as there were in the 3 preceding groups with sucrose above 181 lb per ton.

INTRODUCTION

Sugarcane in Louisiana actively grows for only about 7 months. Freezes may occur early in November, 2 - 3 weeks after harvesting begins, so it is important to select varieties with high sucrose and early maturity.

For many years varieties did not possess a combination of high sucrose and acceptable tonnage. The frequency of varieties superior in tonnage to CP 44-101, the standard used for cane per acre yields from 1950 - 1971, has been low (unpublished data). Varieties superior to CP 44-101 in tonnage have failed to meet other qualifications necessary for a good variety for Louisiana (5). However, the frequency of varieties equal to this standard in vigor has increased in recent years (unpublished data). CP 61-37 and L 62-96, released in 1967 and 1969, respectively, are equal to CP 44-101 in cane per acre (3, 4).

CP 48-103, a high sucrose variety, was the sucrose standard from 1956 - 1970. Varieties L 60-25 (released in 1966), L 62-96, and L 65-69 (released in 1972) are superior to CP 48-103 in sucrose (3, 4). CP 65-357, a promising unreleased variety, is a high tonnage variety that is also superior to the sucrose standard (4). The objective of this study was to determine if, in fact, the frequency of high sucrose varieties in the testing program had increased.

MATERIALS AND METHODS

Yields of sugar per ton of cane were determined for 550 experimental CP varieties tested in the plant cane crop of the replicated yield trials at the Houma Sugarcane Field Station over a 20-year period. Varieties with high sugar per ton yields indicate that these varieties are high in sucrose. Each experiment was conducted with 2 - 3 replications in a randomized block arrangement. Plot size was 1/134 acre. Fifteen to 20 stalk samples were taken from each plot, analyzed for juice quality, and yield of sugar per ton of cane calculated using the Winter-Carp-Geerligs formula (1).

There was considerable fluctuation in sucrose from year-to-year so varieties were grouped by 5-year test periods and the average sugar yield for each group was determined. In this way, varieties could be compared to performance of the groups, to each other, and to the standard varieties.

A value was calculated for CP 48-103 because this variety was not in the experiments during 1952 - 1956. During this 5-year period (109 outfield experiments), CP 48-103 was 120% of CP 44-101 in yields of sugar per ton of cane, so yields of CP 48-103 were calculated at 120% of CP 44-101 yields.

RESULTS AND DISCUSSION

During the first 5-year period (1952-1956) the average sugar per ton of cane for all varieties tested was 181 lb and 27.4% of the experimental varieties were equal to or exceeded CP 44-101 (Table 1). CP 44-101 was the standard used for both tonnage and sucrose. The average for all varieties (181 lb) was close to the sucrose standard (188 lb).

Table 1. Average yields of sugar per ton of cane (S/T) for the years 1952 - 1956.

Year	Series no.	No. of varieties	S/T	Equal or above CP 44-101	
				No.	%
1952	1950	24	186	3	12.5
1953	1951	21	188	9	42.9
1954	1952	37	176	6	16.2
1955	1953	22	169	11	50.0
1956	1954	9	188	2	22.2
Total		113		31	
Average - all varieties			181		27.4
Average - standard (CP 44-101)			188		
Average - (CP 48-103)			226 <u>1</u> /		

1/ Calculated value.

During the period 1957 - 1961, CP 48-103 became the sucrose standard (2). Varieties being tested were still not rigidly screened for high levels of sucrose during the period. The average sucrose level for this group (176 lb) was actually lower than that in the 1952-56 period (Table 2). Varieties with sucrose equal to or exceeding the new standard were 8.3% of the total. CP 48-103, the new sucrose standard, averaged 209 lb of sugar, considerably higher than the group average. Very little progress in sucrose enrichment was noted during the 1962 - 1966 period (Table 3). The varieties averaged 163 lb of sugar, still appreciably below CP 48-103, which averaged 193 lb of sugar. The number of varieties that equaled or exceeded CP 48-103 rose to 11.8%.

Table 2. Average yields of sugar per ton of cane (S/T) for the years 1957-1961.

Year	Series no.	No. of varieties	S/T	Equal or above CP 48-103	
				No.	%
1957	1955	17	185	0	0
1958	1956	14	177	2	14.3
1959	1957	20	179	0	0
1960	1958	27	158	2	7.4
1961	1959	18	179	4	22.2
Total		96		8	
Average - all varieties			176		8.3
Average - standard (CP 48-103)			209		

Table 3. Average yields of sugar per ton of cane (S/T) for the years 1962-1966.

Year	Series no.	No. of varieties	S/T	Equal or above CP 48-103	
				No.	%
1962	1960	20	165	2	10.0
1963	1961	23	164	4	17.4
1964	1962	36	144	1	2.8
1965	1963	34	168	6	17.6
1966	1964	31	172	4	12.9
Total		144		17	
Average - all varieties			163		11.8
Average-standard (CP 48-103)			193		

During the period 1967 - 1971, however, high sucrose varieties began to emerge (Table 4). CP 48-103 yielded 219 lb of sugar during this period, and the average sugar per ton yields for the group increased to 212 lb. The percent of varieties that equaled or exceeded CP 48-103 rose to 35.0.

Table 4. Average yields of sugar per ton of cane (S/T) for the years 1967-1971.

Year	Series no.	No. of varieties	S/T	Equal or above CP 48-103	
				No.	%
1967	1965	40	212	7	17.5
1968	1966	40	197	11	27.5
1969	1967	36	215	3	8.3
1970	1968	41	193	16	39.0
1971	1969	40	241	32	80.0
Total		197		69	
Average - all varieties			212		35.0
Average - standard (CP 48-103)			219		

One hundred ninety seven varieties were tested from 1967 - 1971, and of these 72 were either equal or above CP 48-103 (Table 5). Forty-eight varieties were at least 10 lb higher than standard. In 1969 only 2 varieties exceeded standard; however, CP 48-103 was very high in sucrose that year.

Table 5. Number of varieties equal or superior to CP 48-103 during the period 1967-1971.

Year	Lb of sugar above CP 48-103						Total
	0	5	10	15	20	25 or more	
1967	2	2	2	0	0	0	6
1968	7	1	1	1	0	2	12
1969	0	1	1	0	0	0	2
1970	2	2	1	6	2	5	18
1971	4	3	6	5	3	13	34
Total	15	9	11	12	5	20	72

Fig. 1 shows the increase in percentage of varieties that equaled or exceeded CP 48-103 in yield of sugar per ton of cane for the 20-year period. The percentage of varieties with high sucrose was small during the periods 1957 - 1961 and increased slightly during 1962 - 1966. However, the number of high sucrose varieties increased rapidly during 1967 - 1971.

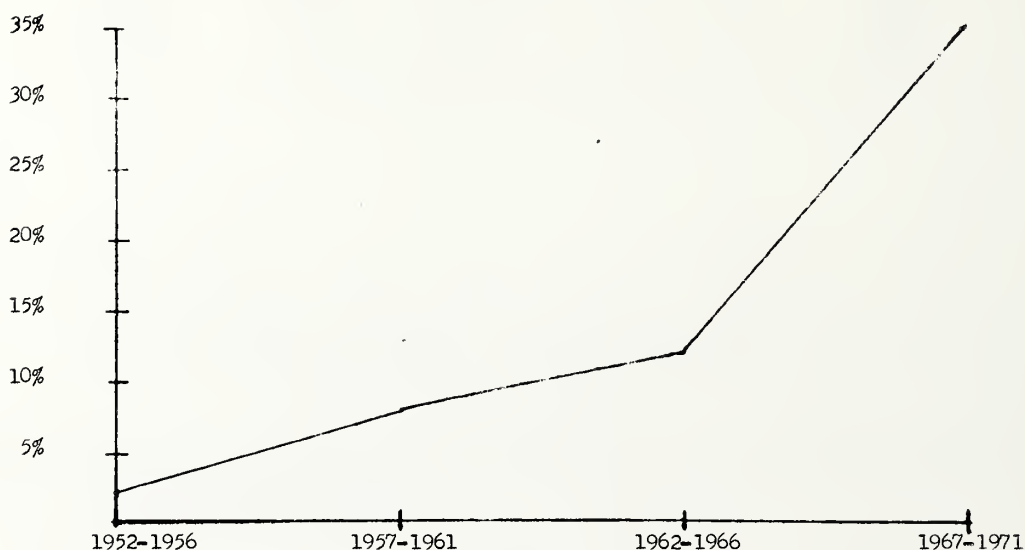


Fig. 1. Percent of varieties equal or superior to CP 48-103 in yields of sugar per ton of cane during the period 1952 to 1971.

The frequency of high sucrose varieties entering the infield tests has increased. This increase is due to the availability and use of high sucrose parents and increased selection pressure for high sucrose and early maturity. The increased frequency of high sucrose varieties at the infield level has made it possible to raise the minimum sucrose for selection and still retain as large a group of varieties in each series to search for the other good qualities necessary for Louisiana conditions.

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SUGARCANE VARIETY TESTING AT THE OUTFIELD
LEVEL IN LOUISIANA

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ABSTRACT

The outfield is the final stage of testing sugarcane varieties before they are released. The experiments are conducted at 13 locations on representative major soil types and growing areas. From 8 - 20 experimental varieties and 5 major commercial varieties are planted in each experiment. The varieties are planted in a randomized complete block design with 4 replications. Outfield experiments are cut by mechanical harvesters from October 15 - December 15. Plant cane, first stubble and second stubble experiments are harvested at each location. Plots are piled and weighed with a tractor mounted hydraulic grab and scale. A random 20-stalk sample is taken from each plot for sucrose analysis. Tons of cane per acre, lb of sugar per ton of cane and lb of sugar per acre are calculated for each plot. An analysis of variance is conducted on each experiment. The experiments are grouped according to soil types, crops and locations, and a combined analysis is conducted before the data are presented. The outfield experiments are also used to obtain variety reaction to mosaic disease and sugarcane borer damage.

The outfield variety program is the final testing stage before varieties are released for commercial production in Louisiana. The program, conducted on 13 sugarcane farms, is a cooperative effort of the USDA, the Louisiana Agricultural Experiment Station and the American Sugarcane League.

The primary purpose of the outfield program is to determine the yield potential of experimental varieties of sugarcane after they have been selected and tested in the seedling and infield stages at Houma and Baton Rouge (2, 7).

The experimental CP and L varieties are compared to 5 released commercial varieties. Yield data on the commercial varieties are also used as a guide in formulating sugarcane variety recommendations for Louisiana.

The outfield variety experiments are conducted on 10 light soil and 3 heavy soil locations. The locations are on representative soil types found in the Louisiana sugarcane growing area. The outfield experiments are maintained in plant cane, first stubble, and second stubble at each location. This is the normal rotation of sugarcane in Louisiana.

The experiments are planted in the 3 major sugarcane growing areas of Louisiana. Seven locations are in the Mississippi River-Bayou Lafourche area, 5 are in the Bayou Teche area, and 1 is in the Red River area.

Several experimental CP and L varieties are introduced at all outfield locations each year. An effort is made to plant progeny of heat treated seedcane for the control of ratoon stunting disease. The new introductions are increased in unreplicated plantings the first year and included in the replicated plots the next year. These introductions and the increase plantings of the other varieties are rogued for mosaic during May and June. These nurseries are normally rogued 3 times during the 2-month period by digging out the diseased plants. The plantings are rogued when the percentages of mosaic are low enough to make roguing feasible.

The outfield variety experiments are normally planted in September and October. The experiments contain from 8 - 20 experimental and 5 commercial varieties planted in a randomized complete block design with 4 replications. The plots are 3 rows wide (approximately 18 ft wide) and 32 ft long with 4-ft pathways. Pathways are included in the plot size for yield calculations and each plot is approximately 1/67 acre in area.

The experiments are planted with hand-cut seedcane at the recommended planting rate of 2 stalks with a 10% lap.

Plot maps are made immediately after planting each location. Wooden stakes are placed in the experiments during the spring. Cypress stakes are painted with exterior water-based white paint and are lettered with dry Marquette ink. The stakes help to identify plots for observation and harvest.

The experiments are cultivated, fertilized, and treated with herbicides and insecticides by the cooperating growers. The experiments receive normal plantation practices, which vary slightly from one location to another.

Mosaic counts are made in the outfield experiments during May. Mosaic spread varies from location to location. Mosaic counts made in the plots are used to determine variety reaction to the disease in areas of low and high mosaic spread (5).

The outfield variety experiments are rated for stand, height, and yielding ability several times during the growing season by using visual ratings. Varieties are graded visually from 1-10 for estimated tons of cane per acre and compared to the commercial checks using the method described by Breaux (1). The visual ratings together with prior data from the infield or outfield tests are used to decide what varieties to advance in the system prior to harvesting the experiments. Notes are also taken during this period on varieties which have lodged or broken due to rain storms or hurricanes.

Mature stalk counts are made in the outfield experiments from September until harvest and used to calculate estimated yields. Stalk number times average stalk weight gives a good indication of plot yields (4). The estimated yields are compared to weighed whole-plot yields obtained in the normal manner. Estimated yields can be used in cases where experiments are too badly lodged to give reliable results by the normal method of harvest.

The harvesting of outfield experiments starts in mid-October and is completed by mid-December. Harvesting begins with the second stubble, followed by first stubble and ends with the plant cane experiments.

The experiments are cut by plantation-owned mechanical harvesters. Stalks missed by the machine are placed on the heap row before weighing. The sugarcane is piled and weighed with a tractor mounted hydraulic loader equipped with a hydraulic load cell attachment (3). In Louisiana, sugarcane is normally burned after cutting; however, sugarcane in the experiments is not burned before weighing so that harvesting can continue during rainy weather. Also, seedcane from the test plots is often used to increase promising new varieties. Burning the cane would damage the buds, and valuable seedcane would be lost.

Trash determinations are made on each variety by removing dry leaves on a 200 lb bundle of cane and calculating the percent trash after it is hand cleaned. Trash normally averages 10% but varies with variety, crop, and condition of cane.

Bored joint counts are made in the outfield plots at several locations at harvest to determine variety resistance to sugarcane borer damage.

Notes on brittleness and lodging are made while plots are being machine cut and used as an indication of the adaptability of the experimental varieties to Louisiana type mechanical harvesters.

A random 20-stalk sample is taken from each plot, and a juice analysis is made on each sample at the Houma Station. Sugar yield is determined by the methods described by Legendre (6).

Yield of tons of cane per acre, lb of sugar per ton of cane, and lb of sugar per acre are calculated for each plot. An analysis of variance is conducted for each experiment for each of yield measures. A combined analysis is normally conducted for several experiments on similar soil types and/or several experiments in a major area in plant cane and stubble crops. Consideration for release is given to experimental varieties which consistently yield better and have other improved characteristics compared to the standard commercial varieties.

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CANOPY CHARACTERS AND THEIR RELATION TO THE YIELD OF SUGARCANE VARIETIES

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ABSTRACT

Breeders see little advantage in selecting sugarcane top characters to improve yield. Characters of the canopy, or top, that might affect yield are the average leaf area, angle, number, thickness, rate of development and the canopy architecture. Variety differences in photosynthesis are small and probably have little effect on variety yield; variety differences in light absorption per unit of land area may be the most significant character of the canopy in relation to yield.

INTRODUCTION

The tonnage of sugarcane is universally recognized as composed of stalk number and stalk weight. Stalk weight is about 78% water, 10% sucrose and 10% fiber. The water is obtained primarily from the soil; the sucrose and fiber are from the photosynthetic combination of carbon dioxide and water. The process may seem inefficient to a society based on chemical engineering. Only one-fifth of the visible light that a leaf absorbs is converted and stored as chemical energy (9), as in sucrose and fiber. While sugarcane leaves may appear poor users of absorbed light, they are very efficient in using the available CO₂. The leaves act as accumulators and withdraw carbon from the air (.01% of the air) and concentrate it almost a thousand fold in the sugarcane stalk (9.3% of the stalk). Photosynthesis also supplies the energy needed to incorporate carbon into fats and proteins and to provide for growth.

Because photosynthesis is related to yield, the differences in varietal yield could reflect differences in varietal photosynthetic efficiency. Among the factors affecting this efficiency are the rate of photosynthesis per unit of leaf area, the effective leaf area of the plant, the leaf area per unit of land area, and leaf display or canopy architecture. The first 3 factors listed are discussed as integral components of the last factor.

PHOTOSYNTHETIC RATE

Sugarcane varieties may differ in the rate of photosynthesis (4), but the rate differences are small and may be obscured by differences in leaf area, and by differences caused by disease or injury, or by changes in light intensity or wind speed (5, 6). Differences in the rate of photosynthesis have been related to leaf thickness and to porosity (4). In further studies with more varieties and a wider range of germ plasm, no significant correlation was found between photosynthesis and leaf thickness or porosity. The width of leaves was the only parameter associated with photosynthesis per unit of leaf area. A study involving 30 varieties with a narrow genetic base showed small but significant varietal differences in photosynthesis, but these were not significantly correlated with thickness, porosity or leaf width (unpublished).

EFFECTIVE LEAF AREA

The effective leaf area per plant is dependent on leaf number and size. These differ significantly with varieties. A preliminary study (unpublished) showed no association between leaf area per plant and yield of sugarcane. However, leaf area per unit of land area (leaf area index) is significantly correlated with yield. The leaf area index is the quotient of the total leaf area of the plants in a plot divided by the area of the plot. A leaf area index of 5 would indicate that 5 acres of leaves occupy 1 acre of land. The leaf area index is a measure of the crop's light and carbon absorbing area per unit area of land, and, when stands are optimal, it can indicate the potential photosynthetic ability of a variety.

CANOPY ARCHITECTURE

The use of leaf area index alone is an oversimplification; not all leaves receive the same light, or the same exposure to wind, or do the same amount of work. The leaves of the individual stalks in a field form a canopy, and some leaves shade others, some are erect, some are horizontal or droop. Canopy architecture, or the leaf arrangement in a field of cane, may be the most seen and least observed feature of a variety. Varieties with distinctive canopies include CP 55-30 in Louisiana and

CP 50-28 in Florida. The identification of varieties from the highway while traveling at a high speed depends on the subconscious summing of canopy characters.

While varietal differences in canopy characters of sugarcane are common, their relation to yield is not known. A variety whose canopy closes early is sought by growers because of its control of weeds by shading. This preference was probably fortified when Co 281 and Co 290 were major varieties. Co 281 with a very narrow canopy of erect leaves, and Co 290 with a wide canopy of droopy leaves provided a clear contrast in the effect of shading on weed control. Breeders still favor varieties that shade the row early, but heavy selection pressure for canopy characters is uncommon.

Skinner (11) reported that bunched seedlings were best selected by the quality of the top. Canes with bad tops were discarded; those with good tops were further evaluated for other characters. Skinner showed that there was a high negative correlation between the condition of the top and arrowing, stating "...in most, but not all, cases poor tops are caused by arrowing." Top condition was also associated with brix and stalk length, but the association was not as great. A later report did not include top condition as a selection criterion, except that a variety was penalized for loss of cover due to arrowing (12). Variety selection based on canopy characters is not a current practice among breeders.

In other crops, higher yields may be achieved through more efficient leaf arrangement. Donald (2) argued that leaf arrangement is critical in selecting the ideal types in breeding programs. He proposed erect leaves and lots of them, and he favored high leaf numbers through high stalk population rather than large numbers of leaves per stalk. Higher stalk populations have the additional advantage of providing greater storage area for the products of photosynthesis. Donald's arguments have been supported experimentally, especially when plants were closely spaced. Matsushima, Tanaka and Hoshino (8) attached weights to the leaf tips of a rice variety with normally erect leaves and depressed carbon assimilation 35%. Pendleton et al (10) tied maize leaves in an erect position and caused a significant increase in yield of grain. Smith and James (13) induced erect leaves in sugarcane seedlings by clipping and recorded an increase in growth. Donald (2) discussed varieties of rice and maize with upright leaves that outyield varieties with horizontal or drooping leaves. A computer modeling study by Duncan (3) indicated that there is a specific leaf arrangement for large and for small leaf area indices that give maximum or minimum yields. A large leaf area index will give maximum photosynthesis if the canopy has mostly erect leaves, and minimum photosynthesis if the canopy has mostly horizontal leaves. A small leaf area index will give maximum photosynthesis with a canopy with mostly horizontal leaves, and minimum photosynthesis with a canopy of mostly erect leaves.

Photosynthesis in sugarcane leaves increases with increasing sunlight, and there is no saturation with the intensities of natural light. The rate of photosynthesis is maximum when the sun is perpendicular to the leaf; light at other angles and shading will cause reductions in the rate of photosynthesis (1, 4). Light from morning and afternoon sun would be nearer to perpendicular on upright leaves; light from the mid-day sun would be nearer to perpendicular on horizontal leaves. Many cane leaves are neither perfectly erect nor horizontal, but are at an intermediate angle, and are curved rather than straight. Curved leaves would have light perpendicular to different parts of their surface as the sun moved through its solar arc. Canopies with upright leaves receive more perpendicular light in early morning and late afternoon and less during mid-day; although shading is more pronounced early and late, the mid-day sun penetrates deep into the canopy. Canopies with horizontal leaves receive less perpendicular light during morning and afternoon hours and more during mid-day; shading is much more pronounced than in upright canopies during mid-day.

Leaves must absorb the most light and carbon dioxide possible for maximum yields to be achieved. The absorption of CO_2 depends on how rapidly that which is absorbed from the air is replaced in the air surrounding the plant. Replacement occurs by diffusion, or more rapidly by air movement (wind). Observations in a cane field with a well developed canopy show that when air moves at 12 mph 1 ft above the canopy, it is less than 1 mph within the canopy. While the youngest, upright leaves may be in the 12 mph zone, the major portion of the crop's leaf surface is the region where air renewal is very slow. The canopy itself thus forms a real barrier to the renewal of air and CO_2 .

This barrier is almost non-existent during the 1st few months of a new crop, and CO_2 renewal is rapid. However, leaf area is small, and most of the available light falls on bare ground. The development of tillers increases the leaf area index, and further growth causes the canopy to develop and close in. As this happens, light absorption increases but the renewal of CO_2 is impeded. More of the available light is absorbed, causing a more rapid fixation of carbon from a decreased supply of CO_2 .

CANOPY AND ROW SPACING

Light absorption can be further increased and CO_2 renewal further impeded by moving the rows closer together. This can also cause dramatic increases in yields. Air sampling in a row-spacing experiment showed that CO_2 levels dropped further in plots with close row spacing and that the decrease is greatest near mid-day. That these lower levels were not enough to limit yields is indicated by an 18 ton increase in cane in closely spaced rows (7).

Row spacing is important in selecting varieties for increased photosynthetic potential. Increased potential is readily obtained by increased leaf area. This can be achieved by increasing the number and size of leaves, and the number of stalks on the row, and by decreasing the distance between rows. Increased efficiency through optimum canopy architecture is predicted to depend on the leaf area index (3). Wide row spacing automatically reduces the leaf area index (2, 3); selection for canopy architecture on wide rows may not produce higher yielding varieties.

Tropical sugarcane has a crop life of 12 - 24 months and rapid development and horizontal or drooping leaves promote early covering of the rows. Canopy development is early and remains intact until the crop is 7 - 9 months old. Frequent lodging then disrupts the canopy, causing temporary shading of some tops and the exposure of bare ground. Light absorption is then reduced, but CO₂ renewal and absorption may increase due to turbulence in the irregular field. Temperate zone sugarcane has a crop life of 8 - 10 months; slow early growth and wide row spacing retard the covering of the bare land by leaves and cause a low leaf area index. Once developed, the canopy usually remains intact. If wide row-spacing is necessary, the more efficient temperate zone varieties should have a large leaf area index with few upright and many horizontal or drooping leaves. However, maximum yields of sugarcane in the temperate zone would be expected on narrow rows with a variety which tillers early and at a wide angle, creating a larger leaf area index earlier in the season. This variety, as the crop ages, should form a canopy of mostly erect leaves on a large number of stalks.

We should reexamine the merit of variety selection using canopy characters. Total light absorption is correlated with yield of cane and can be measured with a light meter as fast as one can walk a plot. Observation of the average leaf angle can be made at a glance. While determinations of leaf area indices are tedious, they can easily be indicated by light absorption. However, any selection system for temperate cane varieties should consider varieties with narrow canopies and erect leaves for narrow rows, and varieties with wide canopies and horizontal or drooping leaves for wide rows.

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MAIZE DWARF MOSAIC VIRUS SUSCEPTIBILITY IN
PARENTAL LINES OF SUGARCANE

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ABSTRACT

Many Louisiana commercial varieties of sugarcane have been found to be susceptible to infection by maize dwarf mosaic virus (MDMV) when mechanically inoculated in greenhouse tests. MDMV has not been identified from naturally infected sugarcane, however. A survey of parent species and interspecific hybrids was made to determine the source of this susceptibility. The results show that Saccharum officinarum var. Louisiana Purple, Louisiana Striped, D-74, Vellai, Lahaina, Crystalina, Bandjarmasin Hitam, Badila, and Otaheite; S. spontaneum var. Coimbatore and US 56-15-8; S. robustum var. 57 NG 55; and interspecific hybrids Kassoer, Co281, and POJ 2878 are not susceptible to MDMV. In contrast, S. sinense var. Chunnee is susceptible to MDMV. As Chunnee is in the lineage of all of the presently grown commercial varieties in Louisiana, it is probably a source of their MDMV-susceptibility. Not all varieties of Chunnee lineage, however, are susceptible (e.g. Co 281). All parental lines tested are susceptible to sugarcane mosaic virus strain H.

INTRODUCTION

Certain varieties of sugarcane, CP 44-101, CP 48-103, CP 52-68, and NCo 310, all interspecific hybrids of the genus Saccharum, are susceptible to infection by maize dwarf mosaic virus (MDMV) (6). Symptoms are irregular, and many infected plants remain symptomless. These findings were extended by R. L. Tippet of the U.S. Sugarcane Field Station, Houma, La., to include the varieties CP 55-30, CP 61-37, and L 60-25 as susceptible to infection by MDMV. Although the virus could be mechanically transmitted to susceptible sugarcane varieties from these symptomless plants soon after inoculation, the virus often could not be recovered after an infection of more than 3 months, (Tippet, personal communication). In greenhouse experiments, Koike transmitted MDMV to sugarcane seedlings (7) and to the commercial varieties CP 52-68 and CP 44-101 with aphids (unpublished data). Sugarcane naturally infected with MDMV apparently has not been reported. However, MDMV strain A has been collected on naturally infected corn, Zea mays L.; crabgrass, Digitaria sanguinalis (L.) Scop.; itchgrass (raoulgrass), Rottboellia exaltata L. f.; and sweet sorghum, Sorghum bicolor (L.) Moench, (unpublished data) and on johnsongrass, Sorghum halepense (L.) Pers., in Louisiana (8, 9). Only strain A of MDMV has been used in Louisiana sugarcane research.

Since most of the varieties presently grown commercially in Louisiana are susceptible to artificial MDMV-infection, the source or sources of that susceptibility are of interest to breeders. Previous investigations had shown that Louisiana Striped (4) and Louisiana Purple (6) are not susceptible to infection by MDMV. In this study, the results of inoculations of these and other parental varieties and the implications of these results are summarized.

MATERIALS AND METHODS

Sugarcane species and hybrids were vegetatively propagated from clones at the U.S. Sugarcane Field Station, Houma, La. and from the World Collection maintained at Canal Point, Fla. and at Beltsville, Md. The noble varieties (S. officinarum L.) tested were Louisiana Purple, Louisiana Striped, Crystalina, D-74, Otaheite, Vellai, Lahaina, Bandjarmasin Hitam, and Badila. Among the wild canes tested, those assigned to S. spontaneum L. included Coimbatore and US 56-15-8; to S. robustum Brandes et Jeswiet ex Grassl, 57 NG 55; and to S. sinense Roxb. amend. Jeswiet, Chunnee. The interspecific hybrids tested were Kassoer, Co 281, and POJ 2878. Plants from single bud cuttings were grown in steam-sterilized soil in 3-inch peat pots in a greenhouse screened against aphids and regularly fumigated.

One virus source was an isolate of MDMV collected on naturally infected johnsongrass at Cinclar Plantation near Baton Rouge, La., in 1968. The isolate was maintained on johnsongrass in an insect-proof greenhouse. Sugarcane mosaic virus strain H(SCMV-H), which was used as a control for the inoculation procedure, was maintained on the sugarcane variety POJ 234 (1). Sugarcane plants were inoculated at the 1-2-leaf stage. Inoculum was prepared from leaf extracts of infected johnsongrass or POJ 234 diluted with 0.01N sodium sulfite. The inoculum containing carborundum was applied with an artist's airbrush using compressed air (125-150 psi). Young plants of johnsongrass and sweet sorghum var. Rio were also inoculated as a control for the infectiveness and purity of the inoculum. Some cane plants were left uninoculated to detect prior infection and accidental spread by aphids.

The plants were examined for symptoms at weekly intervals for 4 weeks. Sugarcane with mosaic symptoms was assayed on johnsongrass and on Rio and Atlas sorghum. Leaves from 2 infected plants were ground with carborundum and 0.01N sodium sulfite in a mortar. This extract was then inoculated onto the carborundum-dusted test plants by rubbing the leaves between the thumb and forefinger. These test plants were checked for symptoms 1 and 2 weeks after inoculation. Two plants (chosen at random) of varieties not showing symptoms were similarly tested for the virus.

RESULTS

Infection of Rio sorghum with SCMV-H produces mild mosaic symptoms on the leaves, whereas infection with MDMV causes the leaves and spindles to become reddened and necrotic and the plants to become stunted (11, 12). Infection of Atlas sorghum with SCMV-H produces a severe necrosis and reddening of the leaf blades and sheath and stunting of the plants, whereas infection of Atlas with MDMV produces only a mild mosaic. SCMV-H only rarely infects johnsongrass, but MDMV readily infects this plant (8, 12). Thus, these 3 varieties can be used diagnostically to separate these 2 viruses, SCMV-H and MDMV.

The results of the inoculations of parental sugarcane varieties appear in Table 1. The number of plants inoculated varies from 3 to 35. This variation is due to poor germination of canes, such as Crystalina, and the limited supply of some of the canes. When the supply permitted, varieties were inoculated in more than one test. The number of plants of each variety inoculated in a test was 15 or less. Thus, these results represent data from several tests carried out at different times. Of the plants (Table 1) inoculated with MDMV, Chunnee alone showed mosaic symptoms. These mosaic symptoms were green-on-green streaks and appeared milder than the symptoms produced by SCMV-H. The MDMV-symptoms in Chunnee persist in the same plant for at least 6 months. Leaves of two plants of the infected Chunnee from each test were ground and assayed on johnsongrass, Rio, and Atlas. Johnsongrass was infected in each assay and the symptoms produced on Rio and Atlas were those of MDMV. Similar assays of plant samples of the canes showing no symptoms were all negative, indicating that they were not symptomless hosts of the virus.

Table 1. Susceptibility of parental sugarcane varieties to inoculation with maize dwarf mosaic virus (MDMV) and sugarcane mosaic virus strain H (SCMV-H).^{1/}

	:	MDMV						:	SCMV-H					
	:	Number of Plants												
	:	Assay <u>2/</u>												:
	:	:	With	:	Number	:	:	:	:	:	:	With		
Varieties	:	Inoc.	:	Symptoms	:	of Assays	:	+	:	-	:	Inoc.	:	Symptoms
Badila	:	9	:	0	:	1	:	0	:	12	:	7	:	1
Bandjarmasin Hitam	:	10	:	0	:	1	:	0	:	11	:	9	:	6
Crystalina	:	5	:	0	:	1	:	0	:	12	:	3	:	1
D-74	:	8	:	0	:	1	:	0	:	11	:	8	:	8
Lahaina	:	10	:	0	:	1	:	0	:	12	:	5	:	0
Louisiana Purple	:	10	:	0	:	1	:	0	:	12	:	10	:	7
Louisiana Striped	:	32	:	0	:	4	:	0	:	35	:	18	:	14
Otaheite	:	5	:	0	:	1	:	0	:	11	:	5	:	1
Vellai	:	10	:	0	:	1	:	0	:	12	:	4	:	2
Coimbatore	:	35	:	0	:	3	:	0	:	35	:	30	:	24
US 56-15-8	:	10	:	0	:	1	:	0	:	12	:	-	:	-
57 NG 55	:	7	:	0	:	1	:	0	:	11	:	8	:	8
Chunnee	:	35	:	34	:	4	:	37	:	10	:	30	:	29
Co 281	:	23	:	0	:	2	:	0	:	23	:	20	:	19
Kassoer	:	15	:	0	:	2	:	0	:	23	:	-	:	-
POJ 2878	:	20	:	0	:	1	:	0	:	11	:	10	:	4

^{1/} Results of several tests combined.

^{2/} Assay test results on johnsongrass. Two plant samples taken from each variety of each inoculation test. (+) indicates assay plants showing symptoms and (-) those plants not showing symptoms.

All of the varieties inoculated with SCMV-H became infected, except Lahaina. All of the noble canes are susceptible to SCMV-H; apparently Lahaina, Otaheite, Vellai, Badila, and Crystalina, all of which were growing very slowly, were of low susceptibility in this test. US 56-15-8 and Kassoer were in short supply and were not inoculated with SCMV-H. US 56-15-8 is highly resistant to SCMV-H (5), and Kassoer has been reported to be susceptible (2).

The incidence of infection was 80% or more for Rio and johnsongrass with MDMV-inocula, and 91% or more for Rio with SCMV-H inocula. In all cases, the symptoms on these test plants were as expected for these viruses.

In only one case did the controls show a prior infection. Cuttings from one stalk of D-74 produced plants with symptoms. Assays of these plants on Rio, Atlas, and johnsongrass showed that they contained only SCMV. Plants arising from that stalk were discarded from the inoculation test results.

DISCUSSION

Table 2 gives the proportions in which the various parental canes appear in the lineage of Louisiana commercial varieties. This table is based on information in the 1971 List of Sugarcane Varieties prepared by the USDA concerning the World Collection. There is some doubt among breeders as to the exact history of certain crosses. There is also some question of identity among the noble canes. For example, Otaheite, Lahaina, and Vellai are considered by Stevenson to be the same cane whereas other workers would treat these as separate clones (3). Because of the irregularities in chromosomal inheritance in sugarcane, it should not be concluded that all parents participate equally (10).

Table 2. The lineage of interspecific hybrids of sugarcane calculated as a percentage of a parent clone in offspring assuming strictly proportional inheritance.

: Hybrids frequently :												
: used as parents :				Hybrids commercially grown in Louisiana								
	: Co	: POJ	: CP	: CP	: CP	: CP	: CP	: CP	: L	: L	: N	Co
Parent	: Kassoer	: 281	: 2878	: 44-101	: 48-103	: 52-68	: 55-30	: 61-37	: 60-25	: 62-96		: 310
<u>S. officinarum</u>												
Black												
Cheribon ^{1/}	: 50	: 25	: 12	: 38	: 19	: 23	: 28	: 20	: 21	: 30	: 16	
Crystalina	: -	: -	: -	: -	: -	: -	: 12	: 6	: -	: -	: -	
D-74	: -	: -	: -	: -	: 38	: 19	: -	: 19	: 28	: 9	: 12	
Lahaina	: -	: -	: 12	: -	: -	: 2	: -	: 2	: 1	: 1	: 3	
Vellai	: -	: -	: -	: -	: 6	: -	: -	: 3	: 3	: -	: 6	
Other ^{2/}	: -	: 25	: 62	: 12	: 6	: 20	: 12	: 17	: 13	: 16	: 41	
<u>S. spontaneum</u>												
Coimbatore	: -	: 25	: -	: 12	: 6	: 6	: 6	: 7	: 9	: 9	: 6	
Other	: 50	: -	: 12	: -	: -	: 2	: 3	: 4	: 1	: 1	: 3	
<u>S. robustum</u>	: -	: -	: -	: -	: -	: -	: 12	: 6	: -	: -	: -	
<u>S. sinense</u>												
Chunnee	: -	: 25	: -	: 38	: 19	: 22	: 25	: 16	: 20	: 30	: 12	
Other	: -	: -	: -	: -	: -	: 6	: -	: -	: 3	: 3	: -	

^{1/} Black Cheribon same as Louisiana Purple (10).

^{2/} For the purposes of the table, Loethers is considered with the nobles. The term others refers to members of the species which were not inoculated in this test.

Table 2 shows that all of the Louisiana commercial varieties contain Chunnee in their lineage. In addition, this table shows the lineage of some of the other parental varieties tested. The parental clones which were not tested in these experiments have been combined under the species name in Table 2. Some sugarcane varieties which were tested but were not included in Table 2 may be represented in modern varieties. If Bandjarmasin Hitam and Black Borneo are synonymous as suggested by Stevenson (10), then this clone would be in POJ 2878 and its offspring.

Co 281, which is apparently not susceptible to MDMV (Table 1) and which contains Chunnee in its lineage, occurs in the lineage of all of the commercial varieties except NCo 310. It should be noted that all of these varieties have additional sources of Chunnee elsewhere in their lineage.

It may be concluded from these data that Chunnee is the probable source of MDMV-susceptibility in the commercial varieties and that not all hybrids containing Chunnee in their lineage are susceptible.

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SUGARCANE MOSAIC VIRUS TRANSMISSION STUDIES WITH THE
WEST INDIAN SUGARCANE FULGORID

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ABSTRACT

Recent field surveys indicate that the West Indian sugarcane fulgorid, Saccharosydne saccharivora Westwood, is widespread in the Louisiana sugarcane belt. Since the fulgorid is a sucking insect and because of its high populations in some areas of the sugarcane belt, experiments were conducted to determine whether or not this insect is capable of transmitting sugarcane mosaic. Eleven experiments were conducted in screened (40-mesh) insect cages. Field-collected fulgorids in different stages of development were released in cages which contained mosaic-diseased and healthy, mosaic-susceptible test plants. None of the 138 young, susceptible test plants (commercial sugarcane varieties L 60-25, CP 52-68, several noble canes, Chunnee, and sweet sorghum cultivar 'Rio') developed mosaic symptoms following 2 - 3 weeks of exposure to fulgorids in cages containing both diseased and healthy plants. Assay of juice from some sugarcane test plants with suspicious discoloration on their leaves on 'Rio' sorghum plants proved the suspect plants were not infected with mosaic. Thus the West Indian sugarcane fulgorid does not appear to be a vector of sugarcane mosaic.

INTRODUCTION

The West Indian sugarcane fulgorid, Saccharosydne saccharivora Westwood (Fig. 1) has been listed as a pest of sugarcane in many of the Caribbean islands, in Central and South America, and in the southern portions of Florida, Georgia, Louisiana, and Mississippi (2).

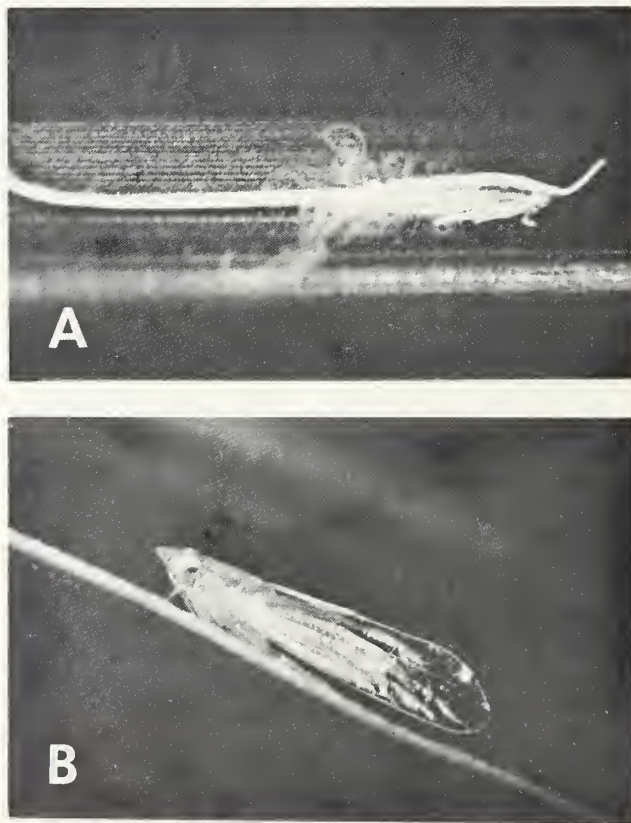


Fig. 1. The nymph (A) and adult (B) stages of the West Indian sugarcane fulgorid.

In Louisiana, the fulgorid has been reported periodically since 1944, and recent field surveys indicate that the insect is widespread in the sugarcane belt of this state (2).

Since the fulgorid is a sucking insect and because of its abundance on sugarcane and johnsongrass in some areas of the Louisiana sugarcane belt, greenhouse experiments were conducted to determine whether or not this insect is a vector of sugarcane mosaic.

MATERIALS AND METHODS

Four cages which were made aphid proof with 40-mesh screen (Fig. 2) were used to conduct the experiments. Virus source plants were placed in 3 of the 4 cages. Cage 1 contained 2 young POJ 234 plants infected with sugarcane mosaic virus strain H (SCMV-H) and SCMV-I, respectively. Cage 2 contained 2 plants each of CP 52-68 and L 60-25 grown from cuttings from stalks which were naturally infected with mosaic in the field. Cage 3 contained 2 plants each of CP 52-68 and L 60-25 which were inoculated with a mixture of SCMV strains A, B, D, H and I. Cage 4 contained no virus source plants.



Fig. 2. Insect cage used in sugarcane mosaic-transmission studies with the West Indian sugarcane fulgorid.

In each of the 11 experiments conducted, 11 or 12 young, healthy cane plants were placed in a cage which contained diseased plants. The healthy test plants were from the mosaic-susceptible commercial varieties CP 52-68 and L 60-25, POJ 234, Chunnee (*Saccharum sinense* Roxb.), and the noble (*S. officinarum* L.) varieties Lahaina, Vellai, Louisiana Purple, Bandjarmasim Hitam, Louisiana Striped, and Otaheite. In 1 of the experiments, 24 healthy sweet sorghum [*Sorghum bicolor* (L.) Moench] cv. 'Rio' plants were placed in a cage which contained mosaic-diseased and healthy cane plants. In cage 4, which contained no diseased plants, a healthy plant from each stalk of cane from which the test plants came was placed. This was done to check whether or not these stalks were diseased, although they did not exhibit mosaic symptoms.

The fulgorids were collected from the field a few weeks before the experiments were started and reared in an aphid-proof cage which contained healthy sugarcane and johnsongrass [*Sorghum halepense* (L.) Pers.] plants. This served as the initial source of fulgorids for infesting cages 1, 2, and 3. Plant tops with the fulgorids in different stages of development (egg masses, nymphs and adults) were removed and placed in the cages with the diseased and healthy test plants. The healthy test plants were exposed to the fulgorids for 2 - 3 weeks. The test plants were then taken out, sprayed with an insecticide and placed in an insect-proof greenhouse. The greenhouse was fumigated weekly with nicotine sulfate. After removal from the cages, the test plants were replaced with new healthy test plants. The process was repeated several times. The cages were periodically re-infested with field-collected fulgorids to insure a continuous high population of the insect in the test cages.

The test plants which were removed from the cages were observed for mosaic symptoms for four weeks. Juice from leaves of plants with questionable discoloration was inoculated into healthy 'Rio' sorghum plants, using the leaf-rub method. 'Rio' sorghum is a good indicator plant for sugarcane mosaic.

RESULTS AND DISCUSSION

None of the 138 mosaic-susceptible sugarcane and 'Rio' sorghum plants developed mosaic symptoms following 2 - 3 weeks of exposure to fulgorids in cages which contained both diseased and healthy plants. Bioassay on 'Rio' sorghum with juice from some sugarcane test plants with questionable leaf discoloration proved that the suspect plants were not infected with mosaic.

There were ample evidences of the movement of the fulgorids within the cages. Numerous egg masses as well as nymphs and adults of the insect were observed on the healthy test plants and mosaic source plants.

Using similar experimental methods, Abbott and Charpentier (1) reported transmission of sugarcane mosaic from diseased to healthy sugarcane plants by 3 aphids.

In preliminary investigations with the fulgorid as a possible vector of sugarcane mosaic and ratoon stunting disease in Florida in 1959, the late D. D. Questel, USDA, obtained negative results (unpublished report).

Our results indicate strongly that *S. saccharivora* is not a vector of sugarcane mosaic.

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THE RATOON STUNTING DISEASE AND GROWTH:
SINGLE-ROOTED PLANTS OF SUGARCANE AND OF SUDANGRASS HYBRID

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ABSTRACT

A single shoot root has the absorptive and conductive capacity to allow apparently normal growth for weeks for shoots of a sorghum-sudangrass hybrid, NB 280S. The growth on single roots was similar whether the plants were healthy or infected with the ratoon stunting disease (RSD). The water loss from shoots grown on single roots was followed gravimetrically for more than 4 weeks; the water loss from RSD-infected plants consistently ranked lower than that from healthy plants, but there was no difference in the average fresh weight of the shoots when the experiment was terminated. The capacity to transport water of a sudangrass-hybrid root, 2 mm in diameter and with a central cylinder 1.1 mm^2 in area, can exceed 430 g per 24-hr period.

INTRODUCTION

A blockage in water conduction appears to be a characteristic of the ratoon stunting disease (RSD) in infected uprights of the sorghum-sudangrass hybrid NB 280S (1). Blockage in infected uprights is indicated both by the characteristic pattern of wilting and by the pattern of declining water usage. This blockage has been attributed to an obstruction in water flow in the region of the junction of sett and mother shoot; it is through this stem region in the upright that all supplies from the root system to the aerial stool must be channeled. No other region of the stem which is so small is so responsible for water conduction in the conventionally grown plants, and conventionally grown plants, when infected, do not show the characteristic pattern of wilting observed in infected uprights (1).

The obstruction in infected uprights may be associated specifically with the stem or associated generally with any highly delimited area responsible for conduction. It was decided to test the latter alternative by the use of plants supported on single roots. Weaver and Zink (4) showed that some grasses can be grown for months, from seedling to flowering, on a single root.

If there is a localized obstruction, the plant has 2 compensating mechanisms available: transport through alternative channels and an increased velocity of conduction (3). The efficiency of these compensating mechanisms may be such that even a relatively large percentage of the conduction cross-sectional area may be occluded without a comparative effect on the amount of water supplied. A blockage is more likely to result in wilting if the obstruction occurs where there are no alternative channels and where transport is restricted to a few vessels.

The supply of water to the shoot is determined not only by conduction but also by root absorption and shoot demand. The absorption of water by the root is determined by soil conditions and by the extent of branching and the health of the root system. The demand of the shoot for water is controlled in part through stomatal opening and closing; when the stomates are open, water loss is determined by leaf area, light, temperature, and relative humidity. The amount of water lost by a plant may be only a small part of the potential capacity of the root for absorption and transport, and of the shoot for transpiration.

If a plant is to be grown on a single root, root performance and shoot demand must be balanced. If the ability of the root to conduct is to be tested, neither root absorption nor shoot demand can be limiting. It was necessary to develop an experimental technique that would allow a large, growing plant to be supplied by a single root.

To grow plants on single shoot roots, the upright was used as the starting preparation. Among the advantages of the upright are its convenience in that it provides the mother shoot and its shoot root with support during the early stages of growth. The length of the shoot root before it reaches the soil can be determined approximately from the distance that the bud, which will give rise to the mother shoot, is above the soil surface. When the mother shoot is severed from the sett, or the sett stalk is cut, the special characteristics of the upright are terminated, and the rooted mother shoot morphologically is like the product of a conventional cutting.

From preliminary experiments, it became apparent that it was not possible to select a root adequate to support a top from a cluster of shoot roots that had reached the ground. The vigor of a root below soil level cannot be judged from the appearance above soil, and it may also be that a root in competition with other roots does not branch as well as a root alone. In the experiment to be described, one of the shoot roots which reached the soil was selected, and all others were trimmed

back. This root was allowed to grow some weeks before the sett was cut, and during this time and subsequently, the other shoot roots were trimmed back as frequently as necessary to prevent their growth into the soil.

The observations and experiments with single-rooted plants, healthy and infected, form the subject of this paper.

MATERIALS AND METHODS

For the sorghum-sudangrass hybrid NB 280S, the methods previously described (1) were used to grow the plants from seed, to prepare setts, to infect with RSD, and to plant as uprights. For this experiment, seeds were sown on May 14, 1971; on July 9, 3-node setts with the end buds excised were prepared, and some of the setts, randomly selected, were inoculated with RSD virus (infected) while others were dipped into heat-inactivated inoculum (control); and on July 12 the setts were planted in 15-cm pots containing a soil-sand mixture. The setts were planted as uprights with the living bud 5 cm above the rim of the pot. After August 3, the shoot roots which had been trimmed back earlier were allowed to reach the soil, and by August 12 the single shoot root to be maintained had been selected. On August 26-27, each intact plant was taken from its clay pot and placed in a polyethylene bag with an additional 250 ml of distilled water. The plastic bags were then placed in styrofoam containers whose shape and dimensions approximated those of a 20-cm pot. The space between the plastic bag and the container was filled with vermiculite and foam rubber to hold up the plants. The container lid was suitably cut and adjusted around the plant so that there was 1 opening for the sett stalk and the shoot root, and 1 opening to permit watering. The lid was sealed to the container with plastic tape, and the openings were plugged with cotton. A wire cylinder was fastened to the container, and the plant was tied with string to this framework so that the plant was fully supported. The plants were returned to the greenhouse. An additional 200 ml of distilled water were added above that lost by the plant. By August 31, all setts had been cut so that the plants were dependent for their supply of water and nutrients on the single shoot roots. A pot planted identically but with the sett and the root cut and the top of the plant removed served as check.

The plants were weighed in the greenhouse, infected and control plants alternately, always in the same sequence. At each weighing, water was added to replace that lost, and the amount which had been added was determined by reweighing the pot. The plants were weighed in the afternoons from August 31 - September 25, mornings and afternoons from September 20 - 24, and mornings only from September 28 - October 1. For purposes of calculation, the 30-day period extends from the afternoon of August 31 to the afternoon of September 21, and from the morning of September 22 to the morning of October 1. Weighings were omitted on 5 rainy days. Water (100 g) in excess of that used was added on September 15 and withdrawn on September 19. The incident energy of sunlight was measured daily by means of a flat-response radiometer placed out-of-doors (1).

Daily records were kept on wilting and guttation and on flowering. For each shoot, records were kept on the date of 1st appearance of the last vegetative leaf (flag leaf), the first appearance of the inflorescence, and the first full exposure of the inflorescence when it was completely free of the sheath of the flag leaf.

On October 1, the plants were moved to the laboratory, and 2 days later the fresh weight of the entire tops was determined, and the diameter of the supporting root was measured. In the following days, the length of all axillaries was measured, and their position in relation to the nodes of the mother shoot was determined. The system of Schoute (2) was used in which the oldest leaf or node is counted as node 1, and progressively younger leaves or nodes have progressively higher numbers.

The diameter of the aerial portion of the supporting root was repeatedly measured with a micrometer both while the root was still intact and after cutting. The spongy nature of the dead cortex made these measurements on the intact root somewhat uncertain. For 2 of the roots, free-hand sections were prepared, stained with 1% safranin, and measured microscopically. Portions of each root were stored under distilled water for 4 days, the cortex was peeled away, and the diameter of the central cylinder was determined with a micrometer. The node of origin of the shoot root which had supported the plant was determined by dissecting away the many stubs of roots which cover the older region of the stalk.

After the stalk had been measured and the insertion of the root had been determined, the stalk was divided into two 3-node setts with the end buds excised. After 2 days in water, the uprights were planted in 10-cm pots in the soil-sand mixture, and they were allowed to grow from October 7 - December 28. The shoot roots were trimmed back repeatedly.

RESULTS

The group of plants from which the single-rooted plants had been selected were allowed to root freely. These plants grew, flowered, and seeded without the characteristic disease symptoms whether they had been inoculated with the virus of RSD (2 plants) or with a heat-inactivated inoculum (5 plants).

That the inoculated plants were infected, and that the control plants were not, was indicated by the results obtained with uprights which had been prepared from the experimental plants after the measurements had been completed. The primary shoots of the uprights from the 6 inoculated plants died, whereas those from the 7 control plants were living and flowering. Uprights that had broken or rooted were discounted.

The experiment was begun with 8 infected and 8 control single-rooted plants. Two of these plants, 1 infected and 1 control, had wilted regularly and the mother shoots eventually died; the root systems of both plants were poorly developed. A 2nd infected plant was discarded when the mother shoot dried out, apparently as the result of competition for water by a very vigorous axillary shoot. When the experiment was terminated, the remaining 13 plants had living mother shoots and a root system within the soil which appeared in excellent health and extensively branched.

The vegetative growth of the mother shoots occurred mostly during the period that the plants had been uprights or uprights with 1 developing shoot root, but the final spurt of growth occurred around the time that the setts were cut and the plant became dependent on the single roots. The average total number of leaves on the mother shoot was 18 both for infected and control plants (Table 1). The height of the single-rooted plants (the length of the mother stalk plus the sheath of the flag leaf) averaged 134 cm for the infected and 146 cm for the control (Table 1).

Table 1. The total number of leaves and the height of the mother shoot, the average daily water loss, and the origin and diameter of single roots which supplied the shoots of a sudangrass hybrid for a month (m.s., mother shoot).

				Supporting root		
				Origin	Diam. (mm)	
Plant	Flag, m.s.	Height	Ave. loss	(Node/		Central
no.	(Leaf no.)	(cm)	(g/day)	shoot) <u>1</u> /	Total	cylinder
<u>RSD-Infected</u>						
2	18	147	189	4/1	1.95	1.25
3	17	137	198	5/1	2.42	1.57
6	18	131	180	5/1	1.77	1.12
7	20	144	192	4 or 5/1	2.02	1.28
10	18	126	201	5 or 6/1	2.04	1.36
16	17	118	164	6/1	2.33	1.40
<u>Control</u>						
4	17	145	186	3/1	2.26	1.38
5	19	136	243	2/1-1	1.96	1.32
8	19	159	233	4/1	2.05	1.31
9	19	168	239	5/1	2.24	1.41
12	16	144	188	3/1	1.66	1.10
13	18	144	217	4/1	1.87	1.30
17	18	127	185	7/1	2.47	1.49

1/ Schoute notation: e.g. 2/1-1 equals the second oldest leaf of an axillary shoot from the oldest bud of the mother or primary shoot.

The fresh weight of the tops of infected and control plants both averaged 206 g, and the range of weights were similar, 177 - 239 g for the infected, and 170 - 243 g for the controls. For the 24-hr period, September 30 to October 1, the loss of water per unit of fresh weight for the infected averaged 0.82, and for the control, 1.00. For the previous day, assuming the same fresh weight, the infected averaged 1.13, and the control, 1.37. The quotient for the infected plants is 82% of that of the controls. The top fresh weight measures a rather heterogeneous combination of inflorescences at various levels of seeding, and of green and dried leaves both on the mother shoot and on the axillaries.

The daily loss in weight varied widely for each of the 13 plants, and the variation appeared to follow the variation in the incident energy of sunlight (1). The month of September 1971, was unseasonably rainy, and very dark and humid days alternated with sunny ones. In Table 1, the losses over the 30-day period are averaged for each plant. In Table 2, the losses for the infected and the controls are averaged for 3 weekly periods, for one 9-day period, and for the 30-day period of the experiment. The average daily incident sunlight outdoors for these periods is also shown. When these averages of weight loss are compared, there is no evidence of a sharp decline in average daily water loss either for infected or control plants. The average water loss for infected plants was less than that for

control plants; after the first week, the infected plants lost about 85% of that lost by the controls. The average daily water loss of the check, the pot with the entire top of the plant removed, was 2.6 g, or about 1.2% of that of control plants.

Table 2. The average daily water loss over 7- and 9-day periods for 6 single-rooted plants infected with RSD and for 7 single-rooted control plants of the sorghum-sudangrass hybrid NB 280S.

Period (1971)	No. days	Average loss Infected	(g/day) Control	Infected	
				Control (%)	Sunlight (cal/cm ² day)
Sept. 1-7	7	172	178	97	206
Sept. 8-14	7	197	225	88	290
Sept. 15-21	7	183	217	84	272
Sept. 23-Oct. 1	9	195	228	85	308
Sept. 1-21					
Sept. 23-Oct. 1	30	183	207	88	272

The supply of water to the plants generally appeared to have been adequate. Guttation drops were noted each morning on some leaves of most plants. Wilting, when it occurred, usually was brief and consisted of the rolling inward of the distal halves of leaves. The appressed leaves, characteristic of the wilting of infected uprights (1), were not observed on the mother shoots. The only time that wilting was more general and included rolling of the entire leaves was on the afternoon of September 12; the leaves of the mother shoot recovered after water was added, and, the next morning, guttation drops were noted on 12 of the 13 plants. It was following this wilting, however, that many of the small shoots from the oldest 2 buds of the mother shoot yellowed and died.

The plants were weighed twice daily for a period of 5 days. As would be expected, water loss during late afternoon and night was a fraction of that lost during the day.

If the data for water loss are to be used for estimating water transport, a balance between uptake and loss must be assumed. On a daily basis, it would seem likely that 2 successive days at similar rates could not be maintained if water loss seriously exceeded absorption and conduction. The maximum rate was measured for plant 5. This plant lost 434 g during the 24-hr period September 12 - 13, and 453 g from September 13 - 14. For the following period, a rainy one, the plant lost 77 g.

For briefer periods, lack of wilting may be considered indicative of a balance of water loss and supply. On September 23, plant 5 lost 300 g between 8:50 a.m. and 3:29 p.m.; and on September 24, it lost 297 g between 8:37 a.m. and 3:34 p.m., without being wilted either afternoon. These losses exceeded the total fresh weight of the top of plant 5, which was 200 g when weighed on October 5. Intermediate weighings on September 23 indicated a rate of loss between 1:45 p.m. and 3:29 p.m. of 45.5 g/hr/mm² of cross-sectional area of the central cylinder of the root; between 3:29 p.m. and 4:25 p.m., of 41.8; and between 5:31 p.m. and 8:37 a.m., of 1.5 g/hr/mm². Hourly weighings on September 24 between 10:45 a.m. and 2:45 p.m. yielded rates of loss of 42.9, 45.5, 40.2, and 42.3 g/hr/mm², respectively. Three other plants were also weighed between regular weighings. The maximum rate obtained for plant 6 was 25.4, for plant 7, 29.5, and for plant 8, 45.5 g/hr/mm². Plant 6 was somewhat wilted in the afternoon of this weighing.

The aerial portion of the root, roughly 5 cm long, consists of an outer brown, loose layer of dead cortical cells and an inner firm, white strand, the central cylinder. The outer portion of the central cylinder contains the vascular tissue and the inner portion, the pith. In terms of the cross-section of the root, microscopic measurements on the supporting root of plants 5 and 6 indicate that the cortical layer constitutes about 60-65% of the total area and that the outer portion of the central cylinder is roughly 25%. The actual area occupied by vessels or their lumen has not been measured but would be a small part of this outer portion. For plant 5, microscopic measurements of the radius of the whole root ranged from 0.908 - 1.062 mm, for the central cylinder, from .548 - .644 mm, and for the pith, from .356 - .438 mm. The variation results, at least partly, from the deviation of the cross-section of the root from the circular and from diameter differences along the root.

When the root of single-rooted plants was selected, it was not possible to determine its node of origin because of the thick cluster of shoot roots. The root of plant 5 did not originate from the mother shoot, but from an axillary shoot. All other roots originated from the mother shoot, from nodes 3 - 7 (Table 2). It may be noted that the 4 plants with roots from nodes 3, 3, 7, and 6 are in 9th, 10th, 11th, and 13th place, respectively, in order of decreasing average water loss.

During the period that the weight changes were followed, the pattern of growth changed from essentially vegetative to flowering. By September 2, all but plant 5 had completed the vegetative development of the mother shoot. In the first 10 days of September, these mother shoots flowered (Table 3).

Plant 5 lagged behind, exposing the flag leaf on September 6, and all of the inflorescence on September 17. During the remainder of the month, many more axillaries exposed flag leaves and many of these eventually had fully exposed inflorescences. Axillary shoots from older buds had begun their vegetative development earlier, but the development of axillary shoots and their inflorescences from the buds of the upper nodes of the mother shoot (nodes 15-19) occurred entirely during the period that the entire stool was supported on a single root.

Table 3. The number and position of shoots that have completed vegetative development and the date of flowering for sudangrass hybrid plants grown on single roots from August 31 to October 1, 1971 (m.s., mother shoot; axil., axillary shoots).

		Shoots with flag leaf, Oct. 1		:			
		from m.s.		:	Date inflorescence first exposed		
Plant	Total	1-n	from	:	axil. from nodes		
no.	no.	(n)	axil.	:	m.s.	1-6	15-19
<u>RSD-Infected</u>							
2	3	2, 17	-	:	909	922	-
3	5	2, 15, 16	1-16	:	910	923	927
6	3	4, 6	-	:	908	929	-
7	3	18, 19	-	:	910	-	1001
10	5	4, 16, 17	1-17	:	905	-	922, 923
16	5	2, 15, 16	1-16	:	904	-	919
<u>Control</u>							
4	3	14, 16	-	:	906	-	-
5	3	1, 18	-	:	917	921	-
8	4	2, 18	1-2	:	910	919	1001
9	5	1, 17, 18	1-1	:	910	916	930
12	4	1, 15	1-1	:	908	915	-
13	4	1, 16, 17	-	:	910	917	-
17	2	1	-	:	908	916	-

When the position of axillaries that have completed vegetative development (flag leaf present) are compared for infected and control plants (Table 3), these points may be noted: 1) Five infected and 6 control plants have axillaries from the oldest nodes (nos. 1-6) of the mother shoot. One infected plant had 2 shoots from the lower nodes. 2) The same number of infected and control plants have axillaries from younger nodes (nos. 15-19) of the mother shoot. Four infected and 3 control plants have 2 shoots each from the upper nodes. 3) The 3 tertiary shoots on infected plants all derive from axillaries from younger nodes, and the 3 tertiary shoots on control plants all derive from the axillaries of older nodes.

When the axillaries with completely exposed inflorescences are considered, 3 of the axillary shoots from the 6 infected plants originated from older buds and 4 from younger buds, whereas 6 of the axillaries of the 7 control plants originated from older buds and 2 from younger buds (Table 3). The sequence of flowering, as measured by the 1st date by which an inflorescence is completely exposed, differs between infected and control plants (Table 3). For axillaries on older nodes, all 6 on the control plants had flowered before any on the infected plants, and for axillaries from younger nodes, 3 on the infected plants flowered before those on the control plants. Plant 16 showed most clearly the shift in infected plants away from the flowering of axillaries from older nodes. This plant, on September 11, was the 1st to begin flowering from a shoot of an older bud (node 2); after September 12, this shoot wilted almost daily, and 20 days later, the inflorescence was still only partly exposed. This plant with 1 axillary wilting was the first, on September 19, to have an inflorescence completely exposed from the axillary shoot of a younger bud (node 16).

DISCUSSION

The outstanding difference between the RSD-infected uprights and the RSD-infected plants on single roots is the absence in the latter of the characteristic wilting and subsequent death of the former. There were several differences in experimental procedure between the pot-weight experiment with infected uprights previously reported (1) and the weighing experiment reported here. In the upright

experiment, the weighing was done in July and early August instead of September, with the result that the daily incident light energy is likely to be greater because of the longer days. The upright experiment was begun with younger plants, which consequently were at an earlier stage of development. In the upright experiment, watering 3 times a day instead of once a day may have offset the more limited waterholding capacity of the smaller soil mass (derived from 10-cm instead of 15-cm pots). Compared to the uprights, the single-rooted plants had a much larger fresh weight, and, generally, a larger daily water loss. If infected, single-rooted plants, like infected uprights, were liable to the characteristic wilting, the age, weight, and water usage of these single-rooted plants would have favored their wilting despite the lesser incident light energy. The results suggest that like the shoots from conventional, infected cuttings, infected plants on single roots can grow indefinitely without the characteristic wilting.

The results of this experiment indicate that the transport of water through the single root and mother shoot of infected plants involves minimum blockage. The water loss in single-rooted infected plants decreased from 97% of the control in the 1st period (Table 2) to 85% in the last; by contrast, the water loss in infected uprights decreased until it had dropped from 90 to 20% of control (1). Infected single-rooted plants supported 2 or more flowering shoots simultaneously, whereas many infected uprights failed to flower or died shortly after bolting. When water transport is blocked in single-rooted plants, the block is between the mother shoot and the axillary shoots, and it occurs alike in infected and control plants. The death of the vegetative axillary shoots from the oldest nodes of the mother shoots, and the repeated wilting of the flowering axillary shoot from node 2 of plant 16, indicate a drastic localized reduction in the water supply at the same time that other axillaries on the same mother shoots are growing and flowering.

Both uprights and single-rooting plants have areas of limited vascular tissue through which the entire water supply to the growing shoot must pass. In infected single-rooted plants, more water passes over a longer distance through an area of vascular tissue probably even smaller than in infected uprights, without wilting and with little or no blockage of the mother shoot. It may be concluded, therefore, that the acute wilting and death of infected uprights must result from a specific blockage of vascular tissue and not from a general inefficiency in transport accentuated by a limited quantity of vascular tissue.

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GROWTH OF SUGARCANE: EFFECTS OF 2 SOIL FUNGI

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ABSTRACT

The effects of Ceratocystis adiposa and Pythium graminicola alone or in combination on the growth of sugarcane in the greenhouse and in the field were determined. In the greenhouse, pregerminated, 1 node setts of varieties CP 52-68 and NCo 310 were planted in infested soil. The 2 pathogens separately caused a significant reduction in total height, fresh weight and dry weight of tops in both varieties. When the 2 pathogens were present together, the reduction was like that of Pythium alone. In the field, after 5 stools each of varieties CP 52-68, CP 61-37, L 60-25, and L 62-96 had been harvested as second stubble, the soil was infested with Pythium and the stubble canes were directly inoculated with Ceratocystis. The growth was measured in terms of the number of shoots per stool the following March after a mild winter. The average shoot number in L 60-25 was reduced significantly by Ceratocystis, Pythium, and by the 2 pathogens together. Pythium alone and both Pythium and Ceratocystis together but not Ceratocystis alone reduced the shoot number in CP 61-37 significantly. Neither fungus reduced the shoot number in CP 52-68 and L 62-96 significantly.

INTRODUCTION

Ceratocystis adiposa (Butler) C. Moreau has been isolated frequently from dead seedpieces of 5 sugarcane varieties, NCo 310, CP 55-30, CP 52-68, CP 62-293, and CP 44-101. The 5 varieties have been succession-planted and grown in the same plots for 8 consecutive years. The effect of this pathogen on the growth of seed pieces in the field has been reported elsewhere (1), but not its effect on the growth of pregerminated 1-node setts in the greenhouse.

Pythium graminicola Subr. has also been recovered from roots of the 5 varieties. This pathogen significantly reduced the total height, fresh weight, and dry weight of top growth of pregerminated 1 node setts of 4 present commercial varieties (4). Although the root rot disease caused by Pythium spp has been of minor economic importance in Louisiana since the introduction of hybrid varieties and of improved cultural practices, Pythium can still cause occasional stand failures with seed-rotting fungi in the spring following adverse winter weather conditions (5).

The combined effects of P. graminicola and C. adiposa on growth of sugarcane varieties have been studied neither in the greenhouse nor in the field. This paper summarizes studies on the effects of C. adiposa and P. graminicola alone or in combination, on growth of pregerminated 1 node setts of 2 varieties, NCo 310 and CP 52-68, in the greenhouse, and the growth of stubble of 4 varieties, CP 52-68, CP 61-37, L 60-25, and L 62-96, in the field.

MATERIALS AND METHODS

Greenhouse studies.

The greenhouse tests comprised 12 replications of each of 4 treatments; Ceratocystis adiposa alone, Pythium graminicola alone, both Ceratocystis and Pythium together, and healthy control. The steam-treated silt loam soil was infested with Pythium, Ceratocystis, or both pathogens just before pregerminated 1 node setts were transplanted into it. Two-week old cornmeal-sand cultures (3) of Pythium or Ceratocystis were mixed thoroughly with steam-treated loam soil in a concrete mixer for 20 min. (inoculum 600 cm³: soil 50,000 cm³). Then the mixtures of soil and inoculum were placed in 12, 9" clay pots. For the combination of the 2 pathogens, half the amount of inoculum from each pathogen was used. Autoclaved mixtures of cornmeal-sand cultures of Pythium (300 cm³) and Ceratocystis (300 cm³) and the steam-treated loam soil (50,000 cm³) were used as control.

One-node setts were taken from mature canes of 2 varieties, NCo 310 and CP 52-68. These greenhouse-grown canes came from plants free of symptoms of mosaic and of the ratoon stunting disease. The setts were germinated in steam-treated vermiculite in 3" peat pots. After 2 weeks, young shoots with roots free of lesions and of similar height were selected, and one shoot was transplanted into each 9" clay pot.

The pots were placed on inverted 6" clay pots on 2 greenhouse benches. They were watered as necessary and care was taken that water was not splashed from pot-to-pot. The tests were conducted in a screened (30-mesh) greenhouse which was fumigated weekly, alternately with nicotin-sulfate and 15% of 0,0,0,0-tetraethyl dithio pyrophosphate. The tests were repeated once.

The growth of primary shoots and tillers for each plant was measured every week for the first 3 weeks, and every 2 weeks thereafter. The total height of shoots per pot was measured from the soil level to the youngest visible dewlap (wedge shaped areas at the junction of the leaf blade and leaf sheath). The tests were concluded at the end of 15 weeks; at this time, the fresh weight and dry weight (oven-dried to constant weight at 90 C for 72 hr) of the tops in every pot were determined after the total height had been measured.

Roots and seedpieces selected at random were checked for the presence of Pythium and Ceratocystis. Water agar amended with 10 ppm of streptomycin sulfate and pimarin was used to reisolate Pythium and cornmeal agar amended with 100 ppm of streptomycin sulfate was used to reisolate Ceratocystis. Pythium was identified from characteristics of oospores that developed on potato-dextrose agar (6), and Ceratocystis was identified from the characteristics of perithecia and ascospores (2) which developed on cornmeal agar.

Field studies.

After the stools of varieties L 60-25, L 62-96, CP 52-68, and CP 61-37 had been harvested as second stubble in October 1971, stools of similar size from each variety were selected and assigned at random to determine the effects of Ceratocystis and Pythium on growth of stubble. This test consisted of 5 replications each of 4 treatments: Ceratocystis adiposa alone, Pythium graminicola alone, both Ceratocystis and Pythium together, and control. The Ceratocystis was inoculated into holes made with a cork borer (diam 2.5 cm) in the cut surfaces of the stubble, and 1 ml of spore suspension was placed into each hole. The Pythium was inoculated into the soil around the root zone of a stool by carefully removing some of the soil, placing 300 cm³ of 2 week old cornmeal-sand cultures of Pythium around the root zone, and then returning the original soil. For the 2 pathogens together, the stools were inoculated directly with the spore suspension of Ceratocystis and the root zone was inoculated with the cornmeal-sand cultures of Pythium. For the controls, the stools were inoculated directly with 1 ml of sterile distilled water and the root zones were inoculated with autoclaved cornmeal-sand cultures of Pythium. The shoot number per stool was counted in March, 1972.

RESULTS

Greenhouse studies.

Top growth of the 2 varieties, NCo 310 and CP 52-68, in control soil or in Ceratocystis infested soil was measurable in the first week after the plants had been transplanted. Ceratocystis significantly reduced the total height of tops 7 weeks after the plants had been exposed to the pathogen.

Top growth of the shoots of variety, NCo 310, in Pythium-infested soil did not occur in the first 3 weeks after exposure to the pathogen. In the presence of both Pythium and Ceratocystis together, there was measurable increase in top growth after 2 weeks. The increment of top growth for these 2 treatments was similar from the fifth week to the end of the test, but it was less than that of the control plants (Fig. 1). CP 52-68 showed similar results.

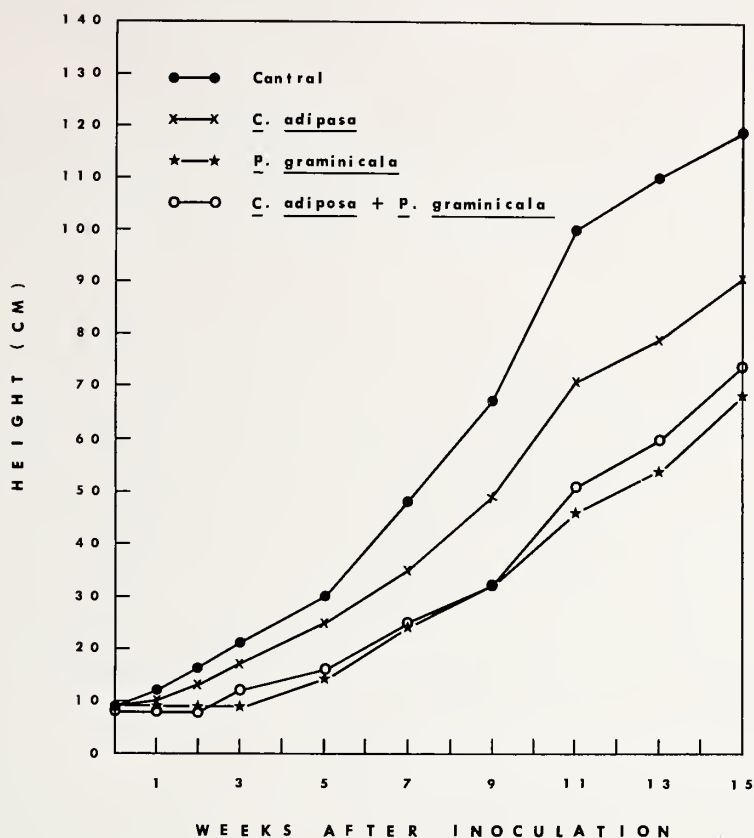


Fig.1. Effect of *Ceratocystis adiposa* and *Pythium graminicola* separately or together on growth of the pregerminated one-node setts of the variety NCo 310.

At the conclusion of the experiment, *Pythium* alone and *Ceratocystis* alone significantly reduced the fresh weight and dry weight of tops (Table 1), the number of tillers in both varieties, and the total height of tops (Table 1). When the two pathogens were present together, the reduction was like that of *Pythium* alone (Table 1).

Table 1. Effect of 2 soil fungi on the top growth of 2 varieties, NCo 310 and CP 52-68, in the greenhouse^{1/}.

Variety	Treatment	Height cm	Fresh weight g	Dry weight g
NCo 310	Control	119 a ^{2/}	294 a	60 a
	<i>Ceratocystis adiposa</i>	91 b	219 b	42 b
	<i>Pythium graminicola</i>	68 c	194 b	34 b
	<i>C. adiposa</i> + <i>P. graminicola</i>	74 bc	187 b	34 b
CP 52-68	Control	112 a	280 a	47 a
	<i>Ceratocystis adiposa</i>	73 b	231 b	37 b
	<i>Pythium graminicola</i>	68 b	231 b	35 b
	<i>C. adiposa</i> + <i>P. graminicola</i>	62 b	225 b	33 b

^{1/} Mean of 12 plants.

^{2/} Means not followed by the same letter are significantly different at the 5% level of probability.

Ceratocystis was reisolated from the old dead seedpieces and Pythium was reisolated from the lesions on roots of plants which had been exposed to the pathogens. Neither Ceratocystis nor Pythium was isolated from the control plants.

Field studies.

The mild winter of 1971-1972 presumably affected the results of the field experiment. Ceratocystis and Pythium, separately and together, significantly reduced the average shoot number in L 60-25, but the effects of the two pathogens together were similar to those of Pythium alone (Table 2). The shoot number in CP 61-37 was significantly reduced by Pythium and by both Pythium and Ceratocystis together, but not by Ceratocystis alone. Neither Pythium nor Ceratocystis significantly reduced the shoot number in CP 52-68 and L 62-96. Soon after the reading was made, the stubbles were plowed out, so no further observations were made.

Table 2. Effects of 2 soil fungi on the tillering of second stubble on 4 varieties of sugarcane in the field.

Treatment	Sugarcane varieties			
	L 60-25	L 62-96	CP 61-37	CP 52-68
Control	8.6 a ^{1/}	8.2 a	11.4 a	6.8 a
<u>Ceratocystis adiposa</u>	4.4 b	7.6 a	8.6 a	4.2 a
<u>Pythium graminicola</u>	5.0 b	4.2 a	3.4 b	5.6 a
<u>C. adiposa</u> + <u>P. graminicola</u>	4.0 b	5.8 a	4.4 b	5.2 a

^{1/} Average number of shoots per stool for 5 replications. Means followed by the same letter are not significantly different at the 5% level of probability.

CONCLUSION

Ceratocystis adiposa alone can reduce total height, fresh weight and dry weight of tops of pre-germinated 1 node setts of the varieties NCo 310 and CP 52-68 in the greenhouse and the average shoot number in L 60-25 in the field. The average shoot number in CP 52-68, CP 61-37 and L 62-96 in the field was not affected by the presence of this pathogen in the stubble pieces.

Pythium graminicola alone reduced the total height, fresh weight and dry weight of tops of the 2 varieties in the greenhouse and average shoot number of L 60-25 and CP 61-37, but not of CP 52-68 and L 62-96 in the field.

The combined effect of the 2 pathogens on the growth of 6 sugarcane varieties in the greenhouse and in the field was similar to that of Pythium alone, indicating no additive or synergistic effect. While Ceratocystis adiposa reduces growth in greenhouse as well as field experiments, its effect is not as severe as that of Pythium graminicola.

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RELATIVE PATHOGENICITY OF ISOLATES OF
COLLETOTRICHUM FALCATUM ON SUGARCANE SEED PIECES

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ABSTRACT

Isolates of the red rot fungus, Colletotrichum falcatum Went, were collected from 15 locations throughout the sugarcane growing areas of Louisiana. These cultures were obtained primarily from the internal tissues of diseased seed pieces, usually from fields showing poor stands. Cultures were obtained from the leaf-scar and root-bank areas of diseased cane as well as from apparently healthy shoots. Since many cultures of the red rot fungus showed sparse sporulation, the use of ultra-violet irradiation was studied as a means of enhancing sporulation. When cultures were exposed to ultra-violet wavelengths of 2537A and 3650A for 3 min., sporulation was greatly enhanced. All cultures that were irradiated with these wavelengths sporulated within 48 hr after exposure. Pathogenicity of isolates that were irradiated with ultra-violet light was not significantly different from pathogenicity of nonirradiated isolates. These findings were quantitated in field studies using 3 varieties of sugarcane. In field tests to determine the relative pathogenicity of 40 untreated isolates, differences were found between isolates and their effect on 3 varieties of sugarcane. The varieties of sugarcane tested were found to differ significantly in their average reaction to these red rot cultures. There were significant differences within the isolates in their pathogenicity. There was an interaction between varieties of sugarcane and isolates of the red rot fungus.

INTRODUCTION

The red rot disease of sugarcane, caused by the fungus Colletotrichum falcatum Went, is an important disease in Louisiana. The fungus causes losses by reducing the number of surviving lateral buds on seed stalks, consequently reducing stands. Red rot has been involved in the failure of important commercial varieties in many areas of the world (19).

Abbott (3) reported the occurrence of 2 distinct morphological groups of the fungus, which he called the light and dark races. The light race produced white to light gray, cottony, floccose mycelial growth; the dark race produced a compact, velvety, dark gray mycelium. Some isolates were intermediate between these 2 races.

The strains of the fungus differ in the degree of sporulation (19). The dark race isolates are generally characterized by sparse sporulation, while the light race isolates normally sporulate profusely (18). This difference in degree of sporulation makes culture and identification work timely.

Inconsistency in susceptibility to the red rot fungus has been noted in the literature. The variety L 60-25 was reported to be resistant to the red rot fungus in 1962 (12) and 1964 (15), but was found to be susceptible in 1965 (14) and very susceptible in 1969 (13).

The present investigation was undertaken to determine the relative pathogenicity of isolates of red rot fungus that were collected from different locations throughout the sugarcane growing areas of Louisiana, and to study techniques for enhancing sporulation in the red rot fungus.

In 1893 the red rot disease of sugarcane was first reported from Java by Went (9). Since that time it has been responsible for losses in some of the sugar producing countries, particularly in India and the USA. Other countries showing high losses from red rot damage are Taiwan and Queensland (19).

The perfect stage of the organism was not known until 1943 when Carvajal reported it from Louisiana (7). The perfect stage was found to correspond with Physalospora tucumanensis, which was described in Argentina in 1896 (7, 8).

Butler (5) reported losses due to red rot in Bengal in 1906. Edgerton (9) reported the disease, and its involvement in seed cane deterioration, in Louisiana and Georgia in 1908. By 1924, some of the noble canes had deteriorated due to red rot to such a point that they had to be abandoned. The variety POJ 213 declined because of red rot and was abandoned in 1931 in favor of the Coimbatore varieties from India. By 1941, Co 290 was declining because of red rot (10).

Abbott (3) in a survey begun in 1930 found that the isolates from Louisiana were all morphologically uniform, producing a light gray to white mycelium on oatmeal agar with slimy pink masses of conidia appearing in 2 - 3 weeks. He also noted that the isolates from the syrup-producing area of

Georgia produced a compact, velvety mycelium that was dark gray in color. A few of the isolates were noted to be intermediate in their characteristics. Abbott pointed out that this was probably an expression of the normal genetic variation (1, 3). Inoculation tests showed both types of isolates produced typical red rot lesions.

Abbott (1, 2) stated that there must exist some physiological specialization in the races of the red rot fungus. He isolated a highly virulent light race from Co 281, a resistant variety of sugarcane.

Went proposed that borer holes provided the main infection site for the fungus (9). Butler (5) and Bulter and Hafiz Khan (6) studied the mode of infection and reported that the fungus could penetrate uninjured cane tissue.

Steib (21, 22) reported that in Louisiana the fungus occurred in the stalk in the latent form. He successfully isolated the fungus from the lateral buds, leaf-scar region and the root-band region of apparently healthy stalks. Steib and Chilton (23) suggested that infection took place sometime during the growing season and lay dormant in these tissues until conditions became favorable for disease development.

Edgerton (9) reported that atypical spores were produced from mycelia in culture and also frequently within the cane tissue. He stated that these atypical spores produced red rot cultures and spores. He suggested that these atypical spores were perhaps immature spores.

Badrudodoza (4) found that the optimum temperature for growth of the fungus lies between 27 and 32 C. He also reported that changes took place in the mycelium of red rot isolates after ultra-violet irradiation. The light type mycelium changed to the dark type after sub-lethal exposure, but not conversely.

Ramsey and Bailey (20) found that ultra-violet irradiation induced a definite stimulation of spore production in cultures of several other fungi.

Resistance and susceptibility of varieties of sugarcane to the red rot fungus has been inconsistent in the past. The variety CP 36-105 was reported by Edgerton (9) in 1955 to be resistant to the red rot fungus. Forbes (11) in 1957, found CP 36-105 to be resistant, and Forbes, Steib and Sanchez (17) in 1960 found this variety to be only moderately resistant to the red rot fungus. Forbes and Giamalva (15) in 1964 and Forbes and Perdomo (16) in 1965 found CP 36-105 to be susceptible.

This same situation is true for some of the newer varieties (12, 13, 14, 15, 16).

MATERIALS AND METHODS

Isolates were collected from many locations throughout the sugarcane growing areas of Louisiana. Most of the cultures were obtained from seed pieces that were planted the previous year and from stubble, usually in areas where poor stands or skips were apparent. The samples were brought into the laboratory where isolations of the fungus were made.

Isolates were cultured on oatmeal agar adjusted to a pH of approximately 4.0, using 50% lactic acid. Isolations were made from seed pieces, young shoots, and leaves of sugarcane that showed visual evidence of red rot and from those that appeared to be healthy.

After 2 transfers on oatmeal agar plates, the isolates were identified and given a number. Sporulation occurred in from 2 - 20 days after inoculation. At this time 41 possible different cultures were given numbers from 1 - 41.

The plates of each isolate were placed in each light condition, which were: 3-min. short-wave ultra-violet light (2537A) in a chromato-vue; 3-min. long-wave ultra-violet light (3650A); total darkness, simulated by wrapping in aluminum foil; and full light from 4, 60W incandescent lamps. Temperature in the laboratory was ca 26 C.

A mycelial plug was removed ca 25 mm from the inoculation point every 24 hr with a flamed no. 4 cork borer. Sporulation was considered to have occurred if one spore could be found in the sample mycelial plug by microscopic examination.

As a field test for pathogenicity of the irradiated isolates, 5 isolates were randomly selected from available isolates. Ten plates of each isolate were plug-inoculated onto oatmeal agar plates and allowed to grow on the laboratory bench under continuous light conditions until full plate coverage had been obtained. Five plates of each isolate were irradiated with 3-min. short-wave ultra-violet light (2537A) in a "Chromato-vue." The remaining 5 plates were left on the laboratory bench under full light conditions.

Inoculum was prepared by adding 10 ml sterile-distilled water to each plant and scraping the mycelial mat with a flamed transfer loop. The spore suspensions from all treated cultures were poured together in a 1 liter flask. The same was done for all untreated spore suspensions. The spore suspension was strained through cheese cloth. The inoculum potential of both suspensions was adjusted by dilution with water to 20 spores per low power field of the microscope.

Three varieties of sugarcane were used in this field test: Co 290, CP 36-105 and L 60-25. Within 48 hr after cutting, the stalks were inoculated by punching a hole approximately in the middle of the stalk in an internode region. Five drops of the suspensions were placed in each hole. Twenty-four stalks of each variety were inoculated with each spore suspension. The 24 stalks were divided into 4 replications, which were buried in the ground, 6 stalks per plot, in a randomized block design. After 6 weeks the stalks were dug and split lengthwise for evaluation. The degree of pathogenicity was determined for each stalk on the basis of the numbers 1-6, depending on the amount of infection present. The categories used were as follows:

- 1 = Confined to 1 internode
- 2 = Disease progression 1 node past inoculation point, nodes solid
- 3 = Disease progression 2 nodes past inoculation point, nodes solid
- 4 = Disease progression 2 nodes past inoculation point, nodes rotted
- 5 = Disease progression 3 nodes past inoculation point, nodes solid
- 6 = Entire stalk rotted

Data recorded from this experiment were analyzed using analysis of variance. Weather conditions during the field experiment did not deviate from normal (25, 26).

Relative pathogenicity of the untreated isolates was tested under field conditions. Forty isolates of the red rot fungus were used in this experiment. These isolates were inoculated onto oatmeal agar and allowed to grow on the laboratory bench under constant light conditions until all isolates sporulated.

Spore suspensions were prepared for each isolate as mentioned in the previous experiment each in a separate bottle.

Three varieties of sugarcane were used in this field test: L 60-25, CP 36-105 and CP 34-120. Three bundles of 6 stalks of each variety were inoculated with a spore suspension of each isolate, as described in the previous experiment. These bundles were buried about 6" deep in the field in a randomized block design with 3 replications.

After 6 weeks, the stalks were dug and split lengthwise for evaluation. Data recorded from this experiment were analyzed using analysis of variance.

RESULTS

Of the root-band areas plated, 20 and 25%, respectively, of the 1st nodes above ground yielded the red rot fungus, dropping to 10% of the root-band regions plated from the 2nd node above ground. No red rot fungus was recovered from the internal tissues of secondary shoots.

Sporulation was observed in 48 hr in 100% of the cultures that had been irradiated with ultra-violet light, ca 2537A, for 3 min. Under continuous light, 73% of the cultures sporulated in 48 hr. Under normal laboratory conditions only 46% sporulated in 48 hr. For 100% sporulation, 264 and 312 hr were required under full light and normal laboratory conditions, respectively.

After finding that ultra-violet irradiation had increased conidial production in the red rot fungus, a field test was conducted to determine if irradiation has any effect on pathogenicity of the fungus. This test showed that there were highly significant differences between the sugarcane varieties, but there was no significant difference between irradiated and nonirradiated cultures. Red rot was reisolated from all treatments.

In the test to determine relative pathogenicity of 40 isolates, it was found that there were highly significant differences between isolates. There was also a significant interaction between varieties and isolates. CP 36-105 was significantly more susceptible than the other two varieties, L 60-25 and CP 34-120; however, several isolates affected CP 36-105 less severely than the other 2 varieties.

DISCUSSION

Isolations made from apparently healthy seed pieces yielded a high percentage of red rot fungus. The red rot fungus was isolated from buds, leaf-scar regions, root-band regions, above and below ground, and leaf sheaths.

Other workers (20-24) had previously found that ultraviolet light stimulated spore production and that perithecial formation occurred in some fungus cultures. In this study it was found that ultra-violet light enhanced spore production in all cultures tested, but no perithecial formation was noted.

This study indicates that ultra-violet irradiation could be used to reduce the time necessary for spore production in cultures of the red rot fungus with no change in their pathogenicity. It was also found that incubation under constant light conditions was more favorable to growth and sporulation than under dark conditions.

In tests conducted to test relative pathogenicity of the red rot fungus it was found that there were differences between isolates and there was an interaction between isolates and varieties. This may be a partial explanation of inconsistent test results that have previously been conducted. Differences in the pathogenicity of isolates cannot be discounted as a factor in disease development.

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CORROSION FATIGUE - ITS EFFECT ON SUGARCANE CHAIN CONVEYORS

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ABSTRACT

Corrosion Fatigue is discussed as it relates to its effect on the parts of sugarcane chain conveyors. A highly destructive form of corrosion occurs when metal parts operating under steady or fluctuating stress are exposed to corrosion. The destructive forces are in the forms of corrosion and corrosion fatigue. Sugarcane chain conveyor pins, when attacked by corrosion, can fail prematurely and without warning, causing expensive downtime. The corrosion occurs on the pins from the cane washing and their contact with the cane juice. Though it's often not recognized, a large number of the premature failures on chain conveyors is a result of corrosion fatigue. Prior to the start of the 1968 grinding season, test pins plated with electroless nickel plating were installed at 4 mills in Louisiana. These test pins were taken out of service for evaluation at the end of the 1971 grinding season. The results of these tests indicate that electroless nickel plated pins offer the sugar mills economical protection against corrosion fatigue failures. The test results, properties of electroless nickel, and its relative cost to other materials and processes are discussed.

INTRODUCTION

Chain conveyors are used extensively throughout the sugar mills. Feed tables, main cane carriers, bagasse and trash conveyors are the main applications for chain conveyors.

These chain conveyors are designed and manufactured to take the normal day-to-day abuses they encounter during the gruelling grinding season. If properly installed and maintained, they normally provide a satisfactory service life.

There are 3 parts in the chain conveyor comprising the joint or bearing area: pins, bushings, and rollers. These parts are subjected to wear during normal operation of the chain conveyor. They are designed and manufactured to offer resistance to the everyday wear forces encountered in sugar mills. Normally, they are not designed to resist corrosive forces they may encounter.

MATERIALS AND METHODS

A particularly destructive form of corrosion occurs when metal parts are exposed to corrosive attack and at the same time are under steady stress or subjected to alternations of stress. The first situation leads to stress corrosion and the second to corrosion fatigue. The situation is far more serious if the metal is undergoing alternations of stress and corrosion simultaneously. The endurance limit (fatigue resistance) may be decreased as much as 70% even though the corroding medium is as mild as tap water (1). Corrosion fatigue tends to reduce service life considerably.

The chain part normally affected the most by corrosion fatigue is the chain pin. The chain pin is a structural member that bends slightly under load. The exposed back side, which is under tension, develops corrosion pits when used in corrosive or wet environments. Corrosion pits on the pins can occur from the cane washing or their contact with the cane juice. The wear side, which is under compressive force, is wiped relatively clean of the corrosive elements by the rubbing contact between the pin and bushing.

Each corrosion pit on the back side of the pin becomes a point of high stress that can develop into a small corrosion fatigue crack. Once the crack starts, it continues to grow as the chain pin is loaded and unloaded until it breaks. A fatigue failure on pins can be identified by the straight-line break through the pin diameter. The break usually occurs near the middle of the pin, where the maximum flexing occurs. A straight tensile or overload failure occurs near the sidebar and has a cupped out break.

The rate at which corrosion pits on pins develop into fatigue cracks and eventually fail is dependent on the severity of the corrosive environment and the unit stress in the pin. As wear progresses, the pin diameter is reduced and the unit stress increases, making formation of fatigue cracks more likely.

Though its often not recognized, a large number of premature failures on sugarcane chain conveyors results from corrosion fatigue of chain pins. At the end of the 1967 Louisiana grinding season, we visited several mills and observed a large number of sugarcane chain conveyor pins that had failed during the season from corrosion fatigue.

The chain conveyor will indicate that pin-bushing wear is progressing as it starts climbing up on the sprocket teeth. The parts can be replaced prior to the wear becoming excessive and before failure occurs. Corrosion fatigue, however, is a silent worker and strikes without advance warning. You could start a new grinding season, confident that your chain conveyor had a couple more years wear life, and the pins could start failing from corrosion fatigue the first week.

RESULTS AND CONCLUSIONS

Certain coatings and platings applied to conveyor chain pins are effective in protecting the back side against corrosion pits. We have observed sugar conveyor pins that had been cadmium plated but the cadmium plating had disappeared in 1 or 2 seasons. We had obtained some good results with electroless nickel plated pins in the coal mining industry back in 1965 and believed this plating would offer effective protection for chain pins against corrosion fatigue in the sugar industry.

Electroless nickel is a nickel-phosphorous alloy (90-98% nickel, 2-10% phosphorous) coating produced by chemical reduction of the nickel ion on a catalytic surface. Electroless nickel has the unusual quality among metals of being non-crystalline. It shows practically no porosity when the base metal has been cleaned properly. Normal hardness is rated at around Rc 50.

Prior to the 1968 grinding season we decided to install some test pins, electroless nickel plated, in the main cane carriers at 4 Louisiana mills. Approximately 20 plated alloy steel pins were installed at each mill, and they were marked for identification. The electroless nickel plating on the test pins was approximately 1 mil thick. A couple of sample pins were removed from the conveyors at 2 mils at the end of the 1968, 1969, 1970 and 1971 grinding season for evaluation.

The electroless nickel plating gave 100% protection against corrosion pits on the critical back side of the chain pins. The plating on the wear side of the pin was removed by wear, but since this side is under compression and wiped clean from wear, no corrosion pitting or cracks occurred.

There are other possible solutions for preventing corrosion fatigue failures of cane conveyor chain pins. Other platings, such as phosphates, could possibly do a good job. Type 420 stainless steel, hardened to approximately Rc 50, has provided excellent service at a number of the Florida sugar mills. However, 420 SS is considerably more expensive than alloy steel pins with electroless nickel plating.

The following chart shows the relative cost of plain alloy steel pins, alloy steel pins, electroless nickel plated and 420 stainless steel pins.

<u>Pin material</u>	<u>Relative cost</u>
8620 Alloy steel - carburized	\$1.00
8620 Alloy steel - carburized and electroless nickel plated	\$1.35
420 SS heat treated	\$2.25

A main cane carrier with 200-ft centers and 2 strands of 6" pitch chain would contain 1600 pins. The pins could be electroless nickel plated for approximately \$600 - 700. This would be cheap insurance against an expensive pin break during the grinding season, plus being able to obtain 2 - 3 times more service life from your chain pins.

When a pin failure occurs in a cane conveyor chain, examine the back side for corrosion pits and the corrosion fatigue failure. If it is evident, investigate the economics of replacing the chain with one equipped with electroless nickel plated pins. From the results obtained in our tests, we believe that electroless nickel plating does an excellent job of protecting the sugarcane chain pins from corrosion fatigue, providing longer service life and reducing maintenance costs. It offers good insurance for its cost against the silent killer - corrosion fatigue.

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POLYMER FLOCCULANTS IN MUD FILTRATION

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ABSTRACT

Different types of new polymers are available from time to time for use in the sugar industry. Some are cationic; others are anionic or non-ionic. Several high molecular-weight polymers are either being used in factory scale operation, or are being evaluated for other applications. Due to different types of soil, cane varieties and other influencing local factors, results of application to juice clarification as well as mud filtration vary from one factory to another. During the 1971 grinding campaign, the performance of several polymers in mud filtration was determined by applying them to filters equipped with a polypropylene cloth. Each polymer was compared with a particular conventional type flocculant. All sets of the test were carried out in parallel under identical operational conditions. Two Eimcobelt Filters of 8 by 12 ft were assigned to each set in the test, and each set was run in duplicate by shifting the dosing of polymer from one filter to another after each run. This duplication compensated for other influencing factors.

INTRODUCTION

Different types of new polymers are available from time to time for use in the sugar industry. Some polymers are cationic, while others are anionic or non-ionic.

Several high molecular weight polymers are being used in raw cane juice clarification. But polymer application as a flocculant for mud conditioning only started in early 1960's, when tests were carried out on vacuum filters covered with a filter medium, e.g. dacron cloth.

Noble (1) investigated the use of polyelectrolytes in mud filtration during the 1970 season in Australia; but all trials in his investigation were carried out on filters which were not equipped with a dacron filter medium.

This paper presents the results of different polymers applied to filters equipped with a polypropylene cloth.

TEST PROCEDURE AND CRITERIA

Due to different soil types, cane varieties and other influencing local factors, results of application to juice clarification as well as mud filtration vary from one factory to another. In order to make results directly comparable, all sets of the test were carried out in parallel under identical operational conditions. Two 8 x 12 ft Eimcobelt filters were assigned to each set in the test, and run in duplicate by shifting the dosing polymer from one filter to another. This duplication compensated for other influencing factors such as newness of cloth, nozzle pressure, etc.

The Separan was fed from the existing stock solution tanks. The comparing polymer was prepared and fed from 4 gasoline drums, with the main header outlet connected to any of the 3 feed pumps (Fig. 1).

The criteria were:

- a. Thickness of cake -- this has been liberally used in sugar mills to indicate the performance of a filter, or a polymer, but actually it carries little meaning alone.
- b. Pol in cake -- this also has been liberally used in literature and very often is misleading. The pol has to be expressed in terms of solids, e.g.:

<u>Pol in cake</u>	<u>Moist.</u>	<u>Solids</u>	<u>Pol/100 solids</u>
4	50%	50%	8
3	70%	30%	10

- c. Weight solids in cake -- for the estimation of the weight of cake discharged. Most mills do not actually weigh the cake; however, this would be a good guide for the estimation of cake produced.
- d. Specific weight of cake -- a direct comparison of cakes of same thickness can be made.

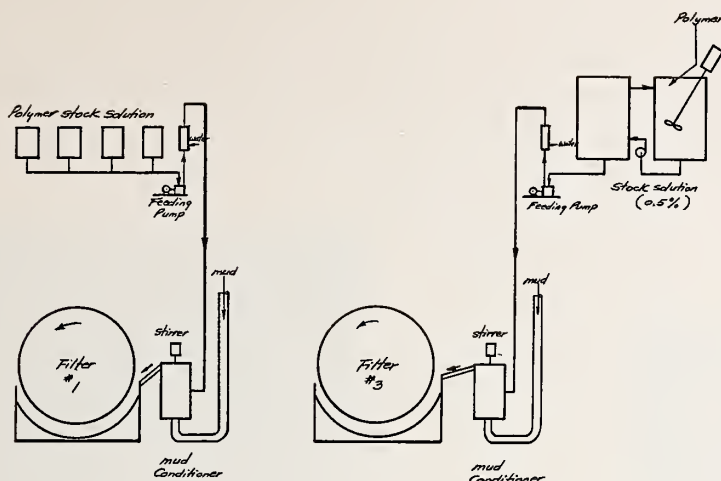


Fig. 1. Polymer dosing device.

POLYMER AS MUD FLOCCULANT

Most of the synthetic polymers used as flocculants for sugar juice clarification are based on polyacrylamide. Because they are synthetic, their composition, molecular size, and flocculating power vary from one manufacturer to another. The rate of settling as a function of molecular weight has been studied by Linke and Booth (2), and the relationship of polymer concentration to bridging effect is shown in Fig. 2.

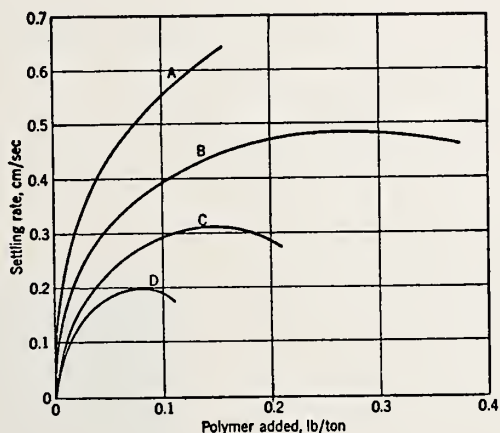


Fig. 2. Effect of molecular weight of polyacrylamide on settling rate of silica dispersion.
 (A - mol.wt. 5,000,000
 B - " " 2,000,000
 C - " " 1,000,000
 D - " " 500,000)

By adding an anionic polymer to the mud of cane juice clarification, the bridging effect of the polymer is shown in the following micrographs taken by a scanning electron microscope. Although the polymer cannot be seen per se, the change of the surface appearance of the mud on treatment with the polymer is clearly noted. (Courtesy, Nalco Chemical Co., Research Center) (Fig. 3-10).

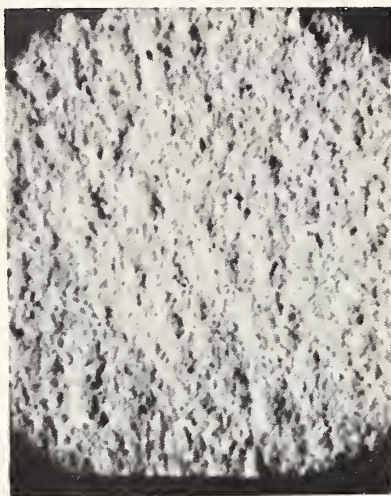


Fig. 3. Sugar Mud, 1000x



Fig. 4. Sugar Mud, 5000x



Fig. 5. Sugar Mud, + 5ppm, 500x



Fig. 6. Sugar Mud, + 5ppm, 1000x

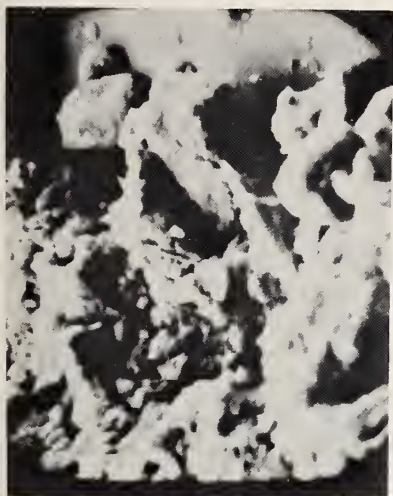


Fig. 7. Sugar Mud, + 10ppm, 1000x



Fig. 8. Sugar Mud, + 20ppm, 100x



Fig. 9. Sugar Mud, + 20ppm, 500 x



Fig. 10. Sugar Mud, + 20ppm, 2000x

COMPARISON OF FLOCCULANTS

Of the polymers that have been tested in our filters, none of them showed comparable results to the conventional Separan AP-30 until Percol LT-26 and Nalco 41A06 were tried and promising results obtained. Percol LT-26 is in solid form, and Nalco 41A06 is in liquid form. Both of them are anionic polyelectrolytes of polyacrylamide, claimed to be of ultra-high molecular weight.

In order to fix one criterion as a constant, for comparing other variables, we chose the thickness of cake as a guide, which is most generally used as an indicator of filtration performance.

While the 2 polymers were being fed into their respective filters, the dosage of both were adjusted until the cakes were similar in thickness and evenly distributed over the whole width of the filter surface. At this time, samples of cake were collected at set intervals from both filters for a period of approximately 5 hr. After shifting the dosing of polymer from one filter to another filter, the same test operation was repeated. Several duplications were carried out for each pair of comparisons.

The results of 2 sets of comparisons can be seen in Tables 1 and 2.

Table 1. Separan AP-30 vs Percol LT-26. (Average of several parallel duplications).

1971 Grinding season	Separan AP-30	Percol LT-26
Cake thickness, cm	1.09	0.94
Cake moisture, %	56.26	55.80
Cake pol	5.78	5.55
Cake weight, g (4 x 5")	160.8	146.6
*** Dosage, 0.5% sol'n liter/hour	204.3	147.3
Calculation		
Wt cake, g/ft ²	1158	1056
* Wt solids, g/ft ²	507	467
Wt pol, g/ft ²	67	59
** Cake pol/100 solids	13.21	12.56
⊕ Cake, specific wt (g/ft ² cm)	1062	1123
Comparison		
* Capacity (wt solids)	100	92
** Pol loss (on solids)	100	95
*** Dosage	100	72
⊕ Specific wt	100	106

Table 2. Separan AP-30 vs Nalco 41A06. (Average of several parallel duplications).

	1971 Grinding season	Separan AP-30	Nalco 41A06
	Cake thickness, cm	0.98	0.92
	Cake moisture, %	53.68	52.30
	Cake pol	6.21	5.59
	Cake wt g (4 x 5")	165.4	153.2
***	Dosage, 0.5% sol'n. liter/hour	126.95	189.30
Calculation			
	Wt cake, g/ft ²	1191	1103
*	Wt solids, g/ft ²	552	526
	Wt pol, g/ft ²	74	62
**	Cake pol/100 solids	13.41	11.72
⊕	Cake, sp wt (g/ft ² cm)	1215	1199
Comparison			
*	Capacity (wt solids)	100	95
**	Pol loss (on solids)	100	87
***	Dosage	100	70-75 ⊕⊕
⊕	Specific wt	100	99

⊕⊕ Converting into same solid basis.

DISCUSSION AND CONCLUSION

The performance of polymer flocculants to mud filtration should not be appraised simply with good or bad thickness of cake, nor a simple expression in terms of pol in cake.

Filtration operation is to dispose of insoluble or settleable solids. It is therefore logical to relate all figures to the total solids being handled.

With all data being on a related basis, direct comparisons can thus be made on capacity, pol loss, and sp wt of cake, etc.

The most effective flocculants are those of high molecular weight. The high mw polymers produce solutions of high viscosity; therefore, more time for preparing the stock solution is needed. Also the particles of high mw polymers may form agglomerates of gel which are very difficult to dissolve. For this reason the preparation of Nalco 41A06 solution was faster with no agglomerates being formed.

The economy of dosage should be compared by converting the quantity used in terms of monetary units. The liquid polymer has a lower concentration than the solid one. It is therefore necessary to use more liquid polymer than the solid one. However, when it comes to monetary evaluation, the overall picture will show the actual saving by each individual polymer flocculant.

ACKNOWLEDGEMENT

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CLEANING AND MAINTENANCE OF HEATING SURFACES IN VACUUM PANS AND EVAPORATORS

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ABSTRACT

Cleaning the liquid side in vacuum pans and evaporators is a routine practice which is carried out periodically, since scaling develops in a short period of time. This presentation deals with the removal of the gradual scaling on the vapor side of calandrias, which takes years to develop and, at times, goes undetected. In modern plants with mills driven by steam turbines, the amount of scaling in vessels operated with exhaust steam is minimal. Our experience shows that the heaviest scaling occurs in calandrias condensing juice vapors from 1st bodies or pre-evaporators, as a result of the distillation of fatty acids and decomposition products from the wax present in the juice. Analytical data are given on the composition of samples of the sludge removed from the outside of vacuum pan tubes. The circulation of a solution of a highly oxidizing agent in the presence of a strong alkali--potassium permanganate and caustic soda--followed by a light acid solution accompanied by a reducing agent--muriatic acid and ferrous sulfate--proved to be the most satisfactory method of several tried at Bryant Sugar House during the past few years. Concentrations of solutions and reaction times of both treatments are described. A schematic diagram describes the technique used in circulating the solutions throughout the calandrias of the vacuum pans. Finally, a description and sketch of traps installed in the steam inlets of the last bodies of the evaporators to prevent iron oxide from entering the calandrias where the galvanic action would cause the deterioration of the copper tubes is presented.

INTRODUCTION

It is easy to judge the fouling of heating surfaces on the evaporation or liquid side in vacuum pans, and even easier in evaporators, since it occurs in a short lapse of time--days or weeks at the most. This is a common problem that, in most cases, is solved with a periodic cleaning based on chemical reactions.

The gradual scaling on the steam side takes years to develop, and at times goes undetected. Often, additional equipment is added to correct the situation instead of restoring the efficiency of heat transfer by proper cleaning.

EXPERIMENTAL

In modern plants, where mill tandems are powered by steam turbines, the amount of scaling on the vapor side of vessels operating with exhaust steam is minimal. However, caution must be exercised in the use of filming amines in the steam boilers to produce a coating on the interior of steam lines in order to protect them during extended shut downs. This practice can produce adverse effects on heating surfaces condensing exhaust or depressurized steam from the boilers, since a similar coating can develop in calandrias, thereby hindering their performance.

There is always a slight distillation of fatty acids in the concentration of cane juice and decomposition products from the wax present in the juice, which are found on the surfaces of calandrias (1).

Our experience adds that the heaviest scaling on the steam side develops in calandrias condensing vapors from the 1st effects or pre-evaporators, and this occurrence increases in direct relation to temperatures at which the pre-evaporators are operated.

At Bryant Sugar House, the vacuum pans are operated entirely with vapors from pre-evaporators. The gradual build-up of scale on the steam side has been observed through the years.

For several years, laboratory tests and factory trials were conducted with different chemical solutions and commercial solvents, but results were not completely satisfactory. Samples of scaled tubes were submitted to different companies whose business is industrial cleaning, but the high cost of chemicals and equipment to perform the cleaning discouraged us from trials.

Samples taken by carefully removing sludge from the outside of copper tubes, using a nylon brush, were analyzed in our research laboratory and gave the composition shown in Table 1.

Table 1. Composition of scale from outside of copper tubes.

Factor	Composition
Moisture	2.21%
Nitrogen (Kjeldahl)	1.38%
Organic matter	57.04%
Iron, as Fe ₂ O ₃	16.90%
Copper, as CuO	11.94%
Potassium	Trace
Calcium	Trace
Carbonate	None
Sulfate	Trace
Chloride	None
Unknown (inorganic oxides)	10.53%

The high concentration of organic matter led us to the use of an oxidizing agent with caustic soda; this treatment to be followed by a solution of hydrochloric acid with a reducing agent to remove the inorganic oxides which were also present in large percentages.

Laboratory tests prior to the trial showed no noticeable corrosive effects from these solutions on copper, cast iron or steel. The following concentrations of water solutions were used:

Solution no. 1

Potassium permanganate	1.50%
Caustic soda	2.00%

Solution no. 2

Hydrochloric acid	0.50% (by weight)
Ferrous sulfate	1.00%
Inhibitor (Rodine 213)	0.03%

Using the caustic soda supply tank and pump, as shown in Fig. 1, solution no. 1 was circulated through the calandrias of our 5 vacuum pans on 3 consecutive days for 8 hr each day.

During the third day, when steam was available at the time of testing the mills and boilers, the solution was heated to 180 F. while being pumped through the pre-heaters. Air was injected with the circulating solution, while keeping the gas lines open, to create agitation inside the calandrias.

After thoroughly rinsing the calandrias with water, the no. 2 solution was circulated, in a way similar to the procedure described in Fig. 1 for a period of 5 hr. No steam was available at this time.

Further inspection of tubes showed that about 80% of the scale deposits had been completely removed, the remaining scale being very soft.

In the last calandrias of our evaporators, it has been the deterioration of the copper tubes after 6 or 7 crops that has given us the most difficulty, rather than the scaling on the outside surfaces. These tubes, becoming brittle, break easily, requiring the calandrias to be retubed completely during the repair season in order to avoid the need for extended repairs while in operation.

The galvanic action of the wet iron oxide deposited on the bottom tube sheets has this detrimental effect on the tubes (1).

To prevent iron rust from entering the calandrias, traps are being installed in the vapor inlets of the evaporators (Fig. 2).

ACKNOWLEDGEMENTS

Special gratitude is extended to Dr. John T. Snow, United States Sugar Corporation, Research Department, and Dr. Hector E. Llorens, Chief Chemist, Bryant Sugar House, for their analytical contributions.

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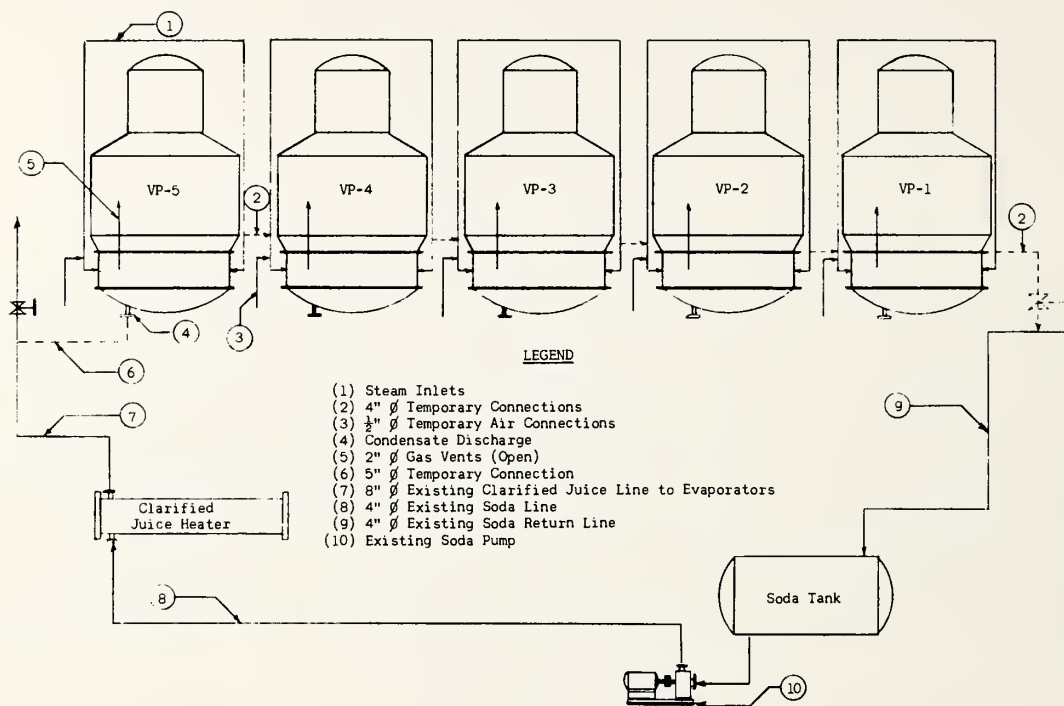


Fig. 1. Flow diagram of cleaning solutions.

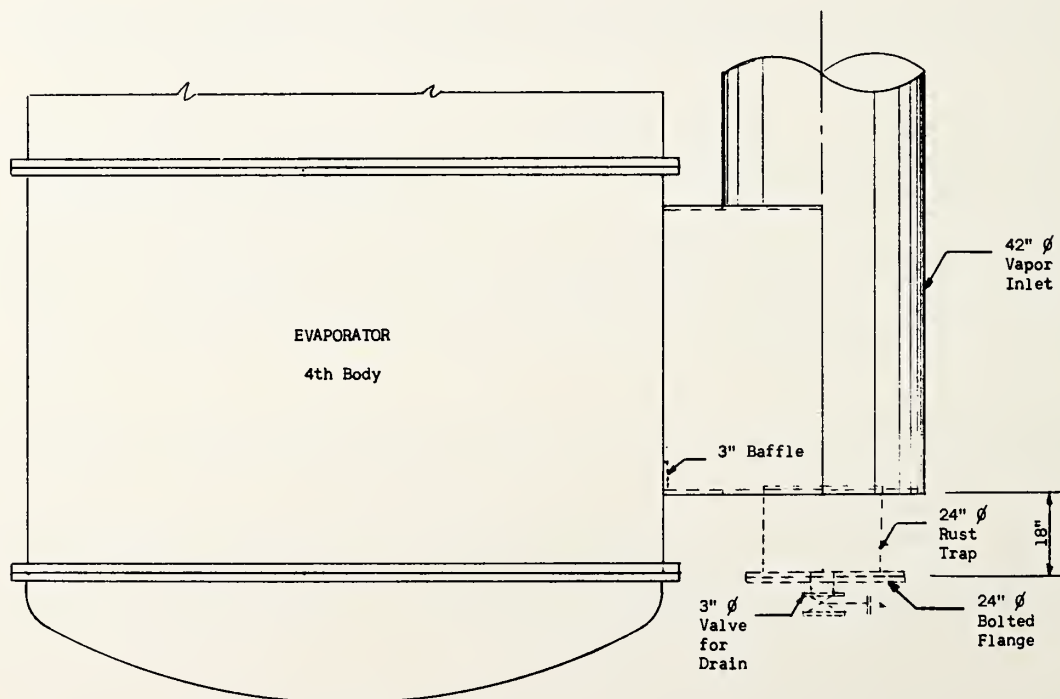


Fig. 2. Rust trap.

COMPREHENSIVE STUDY OF FLORIDA BOILING SYSTEMS

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ABSTRACT

At the present time, there are several boiling systems used in Florida. For the purpose of this paper, they have been grouped into 4 different systems. They are the 2-boiling system, the 2 1/2-boiling system, the 3-boiling system and the Talisman boiling system developed by R. Diago. The scope of this paper is to present a balance of solids and a flow diagram of materials for each of the systems under the theoretical assumption of similar conditions, and to discuss the advantages and disadvantages of them.

INTRODUCTION

There are several boiling systems used in Florida. For discussion purposes they have been grouped into 4; the 2-strike boiling system; the 2 1/2-strike boiling system; the 3-strike boiling system; and the Talisman boiling system, developed by R. Diago (1, 2).

The advantages and disadvantages of these boiling systems as well as the balance of solids, flow diagrams, and amount of water to evaporate at pan stations (assuming similar conditions) are discussed.

Pan flow diagrams show the materials involved, their purities, the solids % syrup solids, and the lb of solids corresponding to 1,000 tons of cane. It was assumed for calculation purposes that each pan station received 260,000 lb of extracted solids of 84.0 purity, coming from 1,000 tons of cane; and that the purities of commercial sugar and final molasses were 99.0 and 34.0, respectively. The 99.0 purity for commercial sugar is very close to the Florida average for the 1970-72 crops; and the 34.0 purity for final molasses is within the feasibility range of most Florida mills. Figures such as strikes, molasses purities, etc., were taken from production reports of the 1970-72 seasons. Since there are 5 sugar mills using the 3-strike boiling system, their average figures were used for calculations.

To calculate the water to evaporate at pan station the brix figures shown in Table 4 were used. It was assumed in the calculations that every system makes magma and melts the C sugar with clarified juice.

2-STRIKE BOILING SYSTEM

It is considered a very good system to use when syrup purities are sufficiently low to control the purity of the C strikes within limits that would produce final molasses of the lowest possible purity. With this system it would be very difficult to produce 99.0 purity sugar and yet get that possible minimum purity in the final molasses.

Referring to Fig. 1, we find that 25.86% of extracted solids from the A molasses produced would be recirculated to the A strike. Of the 23.94% solids of C sugar produced, 6.11% would be used as magma for footing, the rest (17.83%) being remelted and incorporated into the syrup. It has been calculated for the systems that use C sugar for footing, that 1 C magma footing would be cut to produce 24 times its volume in commercial strikes.

This system has the advantage that all the commercial sugar is of uniform quality because it comes from A strikes. This system will produce 5.69 cu ft of strikes per ton of cane, which is slightly lower than the Talisman boiling system and higher than the 3-boiling and 2 1/2 boiling systems (Table 1). It produces less A and B molasses than the 3-boiling system and more than the Talisman and 2 1/2-boiling systems (Table 2). This system has the most water to evaporate, followed by the Talisman, the 3- and the 2 1/2-boiling systems (Table 3).

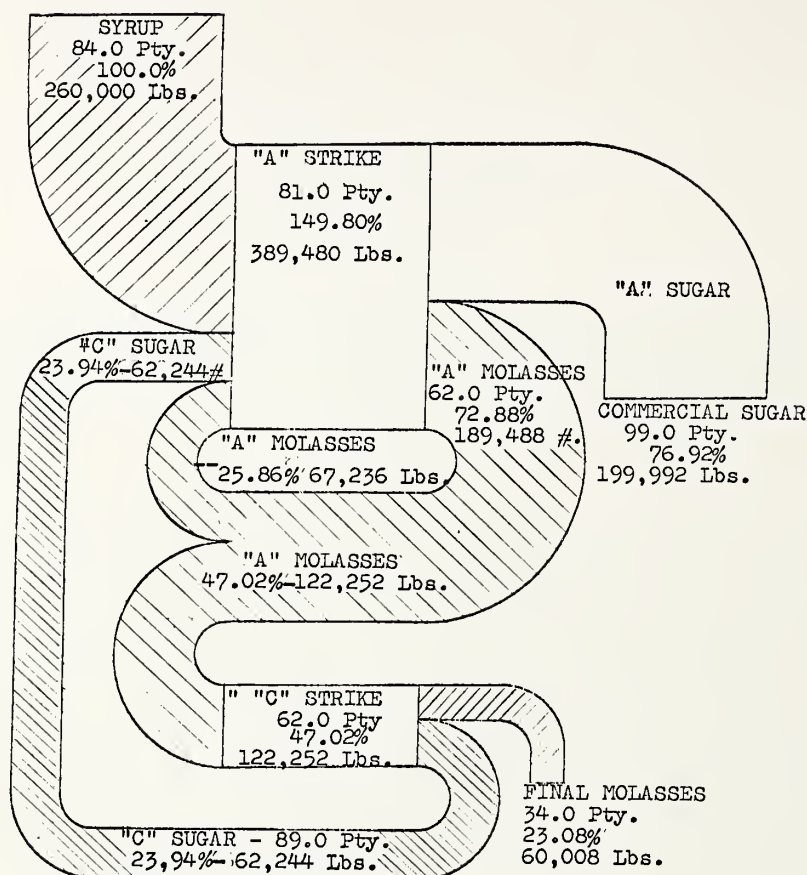


Fig. 1. Two boiling system pan flow diagram.

Table 1. Strike volume for different systems (cu ft/ton of cane).

	Boiling system			
	2-strike	2 1/2-strike	3-strike	Talisman
A strike	4.40	2.27	3.23	3.76
B strike	0	1.89	1.20	0.79
C strike	1.29	1.21	1.20	1.16
Total strikes	5.69	5.37	5.63	5.71

Table 2. Gallons of A & B molasses per ton of cane.

	Boiling system			
	2-strike	2 1/2-strike	3-strike	Talisman
A molasses	26.56	11.73	18.34	18.62
B molasses	-	12.13	8.68	5.52
Total	26.56	23.86	27.02	24.14

Table 3. Pounds of water to evaporate at pan station (per 1,000 tons of cane).

Source	Boiling system			
	2-strike	2 1/2-strike	3-strike	Talisman
Syrup	162,627	163,110	163,252	162,147
Clarified juice for B sugar	-	-	-	4,109
Clarified juice for C sugar	34,610	29,969	28,602	35,122
B sugar	-	-	-	321
C sugar	629	555	543	505
Dilution A molasses	73,718	32,550	50,909	51,677
Dilution B molasses	-	34,803	24,892	15,849
Entering pan station	271,584	260,987	268,198	269,730
In final molasses & commercial sugar	7,069	7,152	7,115	7,069
Water to evaporate	264,515	253,835	261,083	262,661

2 1/2-STRIKE BOILING SYSTEM

This is a 3-strike boiling system in which a B strike of higher purity is made (Fig. 2).

This system has the advantages, as shown in Tables 1, 2, and 3, that it produces less strike volume (5.37 cu ft per ton of cane), less A and B molasses (23.86 gal per ton of cane) and less water to evaporate (253,835 lb per 1,000 tons of cane) than any other system.

The disadvantages are that the commercial sugar is not of uniform quality (a mixture of A1 and A2 sugars), though it would be of better quality than the sugar produced in the conventional 3-boiling system. It seems also that this system would not be able to control the purity of the C strikes at the desirable minimum at all times and conditions.

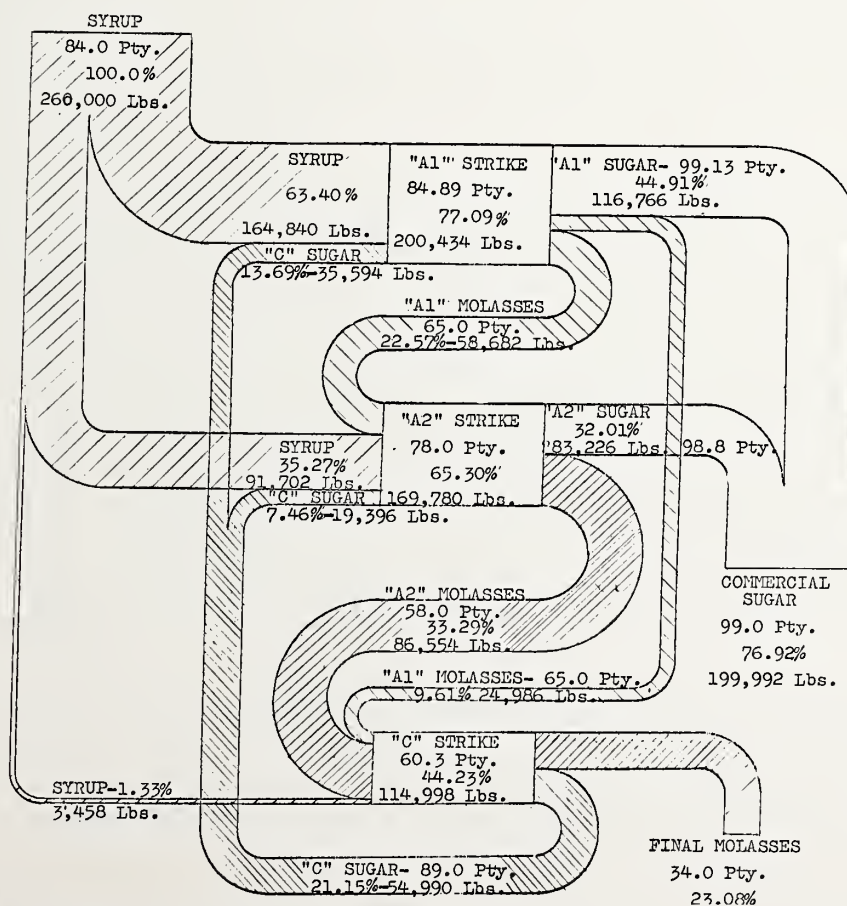


Fig. 2. Two and one-half boiling system pan flow diagram.

3-STRIKE BOILING SYSTEM

There are 5 mills in Florida that use the conventional 3-strike boiling system. As stated before, they have been grouped into 1 in order to be compared with the other systems.

This system produces slightly less strike volume than the Talisman and 2-strike boiling systems and more than the 2 1/2-strike boiling system. The same is true for the amount of water to evaporate. This system produces the largest amount of A and B molasses.

The main disadvantage of this system is that it produces commercial sugar of non-uniform quality. The B sugar, which amounts to 22.72% of the commercial sugar, will be of much lower quality than the A sugar. Attempts to raise the B sugar quality will result in an undesirable high purity of C strikes and final molasses (Fig. 3).

TALISMAN BOILING SYSTEM

This is a 3-strike boiling system in which all the commercial sugar comes from a high purity A strike; the B strike provides B sugar for magma footing and the C strike completes the exhaustion of the final molasses (Fig. 4).

A molasses are full-seeded in the C strike pan. More of the nuclei are added at the proper moment so the pan has sufficient grain for 4 C and 4 B strikes. When the mass has reached the proper volume in the vacuum pan, a footing is cut to the B vacuum pan, so the proper amount of nuclei remain in the C pan and the rest go for the B strike. This footing is fed with the right amount of syrup and A molasses and properly cut in order to obtain 4 B strikes for each footing, as is done with the C strikes. The B sugar grain will double the size of the C sugar, so when used as magma it does not have to be cut so many times in order to have the appropriate grain size in the A sugar. In this way all the B sugar is used as footing, without any melting. All the C sugar is melted with clarified juice and fed to the A strike.

This system produces more strike volume than the others, specially when compared to the 2 1/2-strike boiling system. This means that at the low grade centrifugal station more capacity is required in order to process the B strikes. However, for the commercial sugar station this system processes 3.76 cu ft of A strike per ton of cane to produce the commercial sugar, whereas 4.16, 4.40, and 4.43 cu ft per ton of cane are produced by the 2 1/2-, 2- and 3-strike boiling systems, respectively. So as an average it requires 15% less capacity at the high grade centrifugal station. Another factor that increases the capacity of the high grade centrifugal station is that the A strike has 85.71 purity, which will purge quicker than the other system's strikes. The average purity of the commercial strikes for the 2-strike boiling system is 81.0; 80.40 for the 3-strike boiling system; and 81.73 for the 2 1/2-strike boiling system.

At pan station this system has to evaporate less water than the 2-strike boiling system; a little more than the 3-strike boiling system; and 3.36% more than the 2 1/2-strike boiling system (Table 3). The uniformity in the production of strikes in this system allows for more efficient utilization of the vacuum pan capacity. The advantages of the Talisman system, which will more than overcome any disadvantages, are that, within the same conditions, it produces the best quality, the most uniform sugar, and the lowest possible purity of the final molasses. In other words, the purity of the final molasses will be kept always at the possible minimum for the prevailing conditions, while the quality of the sugar will be controlled at will. For the other systems, there is always a link between the purities of the C strikes, C sugar and final molasses and the quality of the sugar produced. If you try to improve your C sugar purity in order to produce a better quality sugar, you will produce more final molasses of higher purity. In the Talisman system the magma comes from the B sugar, so the C sugar is produced at the lowest purity. Conversely, trying to decrease the C sugar purity in the other systems will adversely affect the quality of the commercial sugar.

The use of highly automated vacuum pan stations with minimum supervision and less skilled labor are expected in the near future. When this time arrives, the Talisman system will be the easiest to automate because of its uniformity. The C and B strikes are produced following the same steps, and all the commercial sugar comes from a A strike made out of magma and mixed syrup.

The advantages of the Talisman system do not indicate that the other systems should be discarded.

The performance of the 2 1/2-strike boiling system is excellent and it will provide a greater capacity for the vacuum pan and centrifugal stations than any other system under the conditions presented in this paper.

When syrups of low purities are to be handled either because of unripe or freeze-damaged canes, the use of the 2-strike boiling system is indicated.

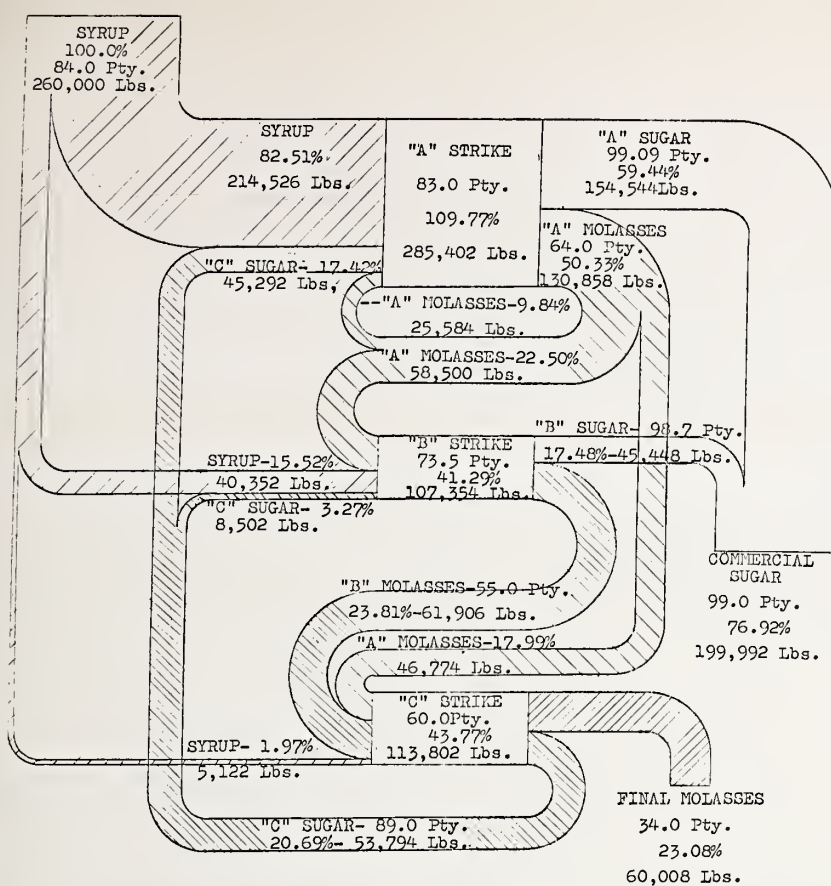


Fig. 3. Three boiling system pan flow diagram.

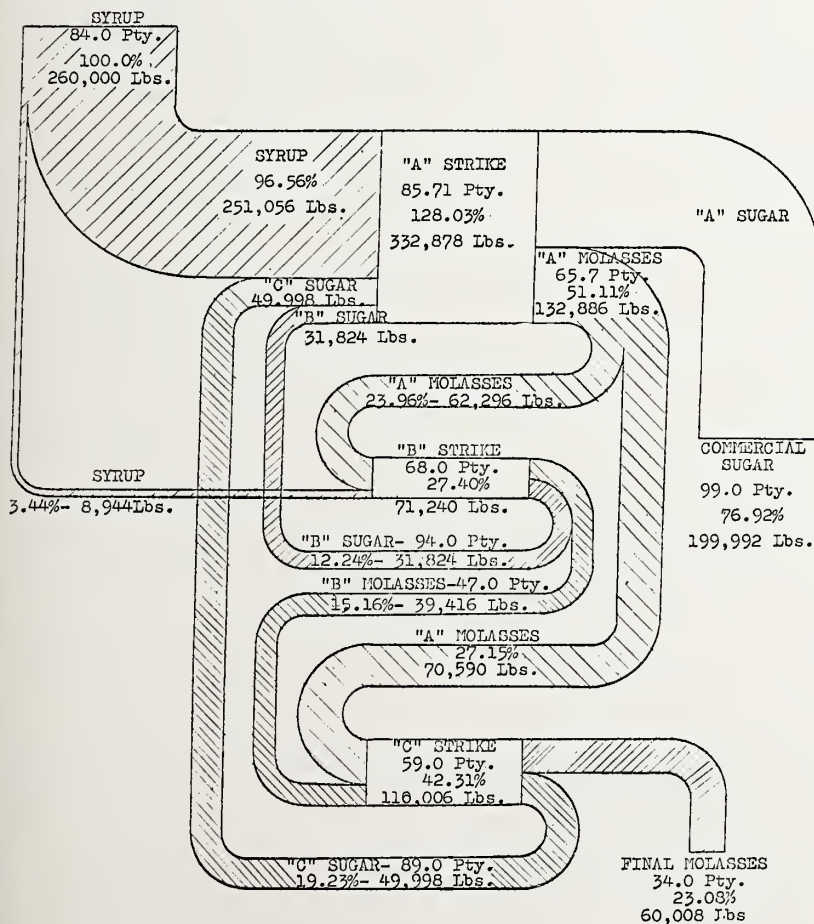


Fig. 4. Talisman boiling system pan flow diagram.

Table 4. Brix of materials at pan station.

<u>Material</u>	<u>Brix</u>
Clarified juice	14.0
Syrup	61.0
C or B sugar magma	88.0
C sugar syrup	61.0
A or A1 sugar	99.8
B or A2 sugar	99.7
B sugar (94.0 purity)	99.0
C sugar	99.0
A strikes	94.0
B strikes	95.0
C strikes	98.0
A molasses (undiluted)	87.0
A molasses (diluted)	65.0
B molasses (undiluted)	88.0
B molasses (diluted)	65.0
Final molasses	90.0

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PRESENCE OF NON-SUCROSE POLYSACCHARIDES IN SUGARCANE
JUICE AND ITS INFLUENCE ON SUGAR RECOVERY

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ABSTRACT

Identification of non-sucrose polysaccharides in sugarcane juice and the effect of these constituents on recovery of sucrose in factory processing are discussed. The origin and causes of this phenomenon are associated with condition of crop and time between cutting and processing. Raffinose is probably one of the major non-sucrose constituents, and, since it is dextrorotatory along with sucrose, it adds to the polarization reading in a saccharimeter. Research conducted on sugarbeets is reviewed and related to false juice pol in sugarcane. Current research may provide a way to cause matation of raffinose to sucrose during factory processing.

The purpose of this paper is to call attention to the observations made in the behavior of the sugarcane juice during the fabrication process under certain conditions, which are particularly reflected in the crystallization and sugar recovery.

Since this phenomenon takes place almost invariably every year, we were motivated to find a reasonable explanation. We have done very little laboratory testing to prove this point and we have found very little information in our cane sugar industry in this respect.

As a sugar manufacturing technician, this paper may seem to be an excuse for a poor performance, but even though we do not want to deny the possibility of that feeling being nested in the back of our mind, it is our intention in presenting this paper to make known the problems that we have encountered which seem similar to the problems found by other technicians. It is our hope that this will serve to encourage a thorough study of this phenomenon, with a complete research program in seeking the solution to one of the most common difficulties that we face every year and which economically means thousands of dollars that could be recovered and are presently lost from our industry without benefiting any one.

For many years we have experienced a condition in our sugar factories that has puzzled us. In Louisiana, especially, we very often have a period during the grinding season when it becomes almost impossible to exhaust the final molasses.

This normally coincides with the 1st rain during the harvesting season. The 1st effect that we notice is a sudden drop of pol in the normal juice because of the natural dilution taking place in the cane. After a while the pol reading is re-established. There is a pronounced rise in pol and purity in the juice. When this happens, we begin to experience difficulties with our final molasses purity and, in general, in sugar recovery.

There is another case, when we process stale cane. The same problem arises in sugar recovery and a final molasses of abnormally high purity is produced. It is our intention to identify what occurs in both cases.

When this condition exists because of what we would call a 2nd growing period of the cane, with interruption of its maturity process, the cane itself is healthy and its content of invert sugar is very low. Last grinding season this was very pronounced. We had figures of glucose ratio as low as 3.5 in dilute juice, with the usual figure for many days around 4.0.

Since we were processing relatively fresh cane at the time and keeping a very low stock in the cane yard every morning, we could not attribute the relatively high purity in final molasses and poor recovery to stale cane.

The symptoms in the pan work were very similar in all the factories that we are in contact with and the others that we visited in the area. The crystallization of the sucrose was erratic. The shape of the grain was elongated, and in many cases needle grains were present. The sugar begins to look like epsom salts. The experience has indicated to us that when we have this condition, exhausting molasses is very difficult and the sugar recovery is affected.

When cane damaged by freeze or any other adverse weather condition or stale cane is processed, the sugar recovery is also affected and exhausting molasses is impaired, but in this case, the invert sugar content is relatively high, with glucose ratio reaching around 12.0.

After the inversion of sucrose into the monosaccharides dextrose and levulose, a subsequent deterioration of invert sugar takes place. In most cases the 2 monosaccharides are in a 1:1 ratio. But when a continued deterioration occurs, this ratio does not remain constant. Because levulose is more unstable than dextrose, it is eliminated faster than the dextrose, thereby altering the 1:1 ratio and showing an abnormal dextrorotatory reading.

If we add to this the formation of some other substances that are optically active and mainly dextrorotatory, we find an explanation for an increase in pol in juice with the false indication of a higher sucrose content, as was very well pointed out in a technical paper presented to this meeting last year by J. C. P. Chen. In this case the sugar recovered does not correspond to the amount of sucrose (pol) entering the boiling house as determined by the regular pol account that we use, and the final molasses purity is also affected.

This is the phenomenon that we have become familiar with and are used to observing. It is well studied and its remedy is within our control. But it is the other case, when we do not have inversion to speak of, and sugar recovery and molasses exhaustion become very difficult, that we are considering in this paper.

Since we were not able to find sufficient information about any research in the cane sugar industry concerning this matter, we have based our conclusions mainly on physical observations of occurrences and evaluated the data that we have on hand.

We have observed the low invert sugar content reflected in low glucose ratio; the elongated shape of the crystals; the consistency of the low grade massecuite that takes the form of a pulpy leaf, reducing its fluidity very appreciably in a continuous crystallizer system; and finally a low amount of molasses but a very high purity. The drop in purity from massecuite to molasses is reduced to a very low level, as low as 8 - 10 points in high grade massecuite and about 20 points at best in low grade final massecuite.

These observations lead us to the beet sugar area where they have studied this matter more extensively. It seems like this is relatively common in that industry and they have been able to determine the cause and its origin. The presence of raffinose and other polysaccharides are responsible for this condition.

Experiments conducted by Devillers and Cornet on crystallization of sucrose in presence of doses from 0 - 2% of raffinose have resulted in the conclusion that the presence of this sugar affects the crystallization of the sucrose. The molecular rearrangement at the surface level of the crystal is very much slowed down by the presence of raffinose, both on the face and on the end of the crystals. With higher concentrations of raffinose, the crystal lengthens into a needle. The raffinose content of the crystal where the growth has been slowed is high; where the growth is not hindered the content is almost nil.

The polysaccharides, as in the case of sucrose and raffinose, are formed in the period of synthesis of the monosaccharides. The sugar that is formed first in this process depends on the molecular arrangement and passes through the stages of other saccharides, such as raffinose, before completing the whole mutation into sucrose.

This is what seems to occur in our case when we experience a second growth of the cane before it reaches complete maturity. That is why these conditions arise following a rain during the harvesting season.

To complicate the situation and make the sugar recovery appear even poorer, we have to consider that the raffinose is optically dextrorotary in the polariscope and every one point of raffinose displaces the saccharimeter to the right to an equivalent of 1.6.

Since the payment of the cane is based on normal juice pol, it can be easily realized how important this condition is as far as cane payment is concerned.

In the beet sugar area they have been able to separate and recover the raffinose. We were informed that their research is almost complete in the search for an enzyme that will accelerate the mutation of the raffinose into sucrose within the manufacturing process. This will allow the recovery of most of the sugar contained in the juice. Let's hope that this enzyme will be available soon and that its use could be applicable to our cane sugar industry.

THE USE OF A 30,000 TON SUGAR SILO
IN THE MOORE HAVEN SUGAR HOUSE

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Moore Haven, Florida

ABSTRACT

The sugar silo has been in use in Moore Haven since the 1969-70 season. Difficulty in conditioning the empty tank was solved by increasing the air-conditioning capacity. Realignment of the support rail eliminated irregularity in tracking of the bridge-support wheel. Eccentricity of slipring contactors was corrected by installing flexible conduit leads. Inability to deliver sugar to meet our moisture quality objectives was alleviated by various operational improvements. Modifications to the temperature exchange equipment corrected thermal-barrier air treatment problems.

Editor's note: Only the Abstract of this paper was available for the Proceedings.

HANDLING OF THE C SUGAR EXCESS

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ABSTRACT

The excess of C sugar magma produced in the sugar industry is generally melted, using a continuous or batch system with the addition of hot water or clarified juice. A cylindrical tank 6 ft in diameter and 10 ft high was installed at Atlantic to use as a melter. The density of the liquid is controlled automatically by a differential pressure transmitter which receives the signal from two air bubbles, one connected to the sugar solution and the other to the chamber of reference filled with glycerin. As soon as we started operating the magma melter our periods between cleanings were increased from 4 to 10 days, which represents 150% more working time. The ash content of C sugar averages 20,000 - 30,000 ppm and 50% of this total is calcium, which we consider a negative addition to our juice volume for the heat transmission of the evaporator's tubes, especially for the 1st bodies.

INTRODUCTION

In the sugar industry usually there is more C sugar magma produced than is needed except when the purity of the cane juice is very high.

This excess of C magma has to be melted using a continuous or batch system with the addition of hot water or clarified juice. The easiest way, generally employed in all sugar houses, is to provide an overflow at the upper part of the magma crystallizer discharging to the evaporator supply tank, where the excess C sugar will dissolve immediately, going through the evaporators with the juice and leaving as syrup.

Another way is to install a tank to use as a melter discharging directly into the syrup tanks at the pan floor without going through the evaporators.

From the beginning Atlantic melted the excess of C sugar produced in the clarified juice tank, but during the last summer, looking for a possibility to improve our evaporators station, we decided to try with a melter.

INSTALLATION

A cylindrical tank, (Fig. 1), 6 ft in diameter by 10 ft high was located on the 1st floor close to the magma pipe line.

This melter was installed with a steam coil at the bottom, and a propeller mixer was located at the top center half of the tank to stir the solution of clarified juice with the C sugar magma coming by gravity from the overflow box installed at the magma seeder.

A baffle plate was fitted at the center of the melter, reaching from 2 ft above the top of the tank down to the bottom of the cone, dividing it in 2 parts, in order to prevent the magma from going to the suction of the pump without being dissolved.

The density of the liquid is controlled automatically by a differential pressure transmitter, which receives the signal from 2 air bubbles, one connected to the sugar solution and the other to the chamber of reference filled with glycerin.

A recorder-controller receives the signal from the transmitter and acts over a 1" valve installed in the clarified juice line. A hot water connection is installed to the 1" control valve in order to be used in case of any failure caused by a mill stoppage.

The level in the melter is regulated by a float which operates an electrical switch controlling a solenoid valve that opens a 4" butterfly valve located on top of the tank, recirculating the sugar solution and keeping the pump working continuously.

A 4" overflow line is installed from the top of the melter to the A molasses tank at the centrifugal station in order to prevent running over because of a pump failure.

A 90-ft head and 230 GPM size 3 x 2 x 11 pump was installed to bring the sugar solution to the syrup tanks.

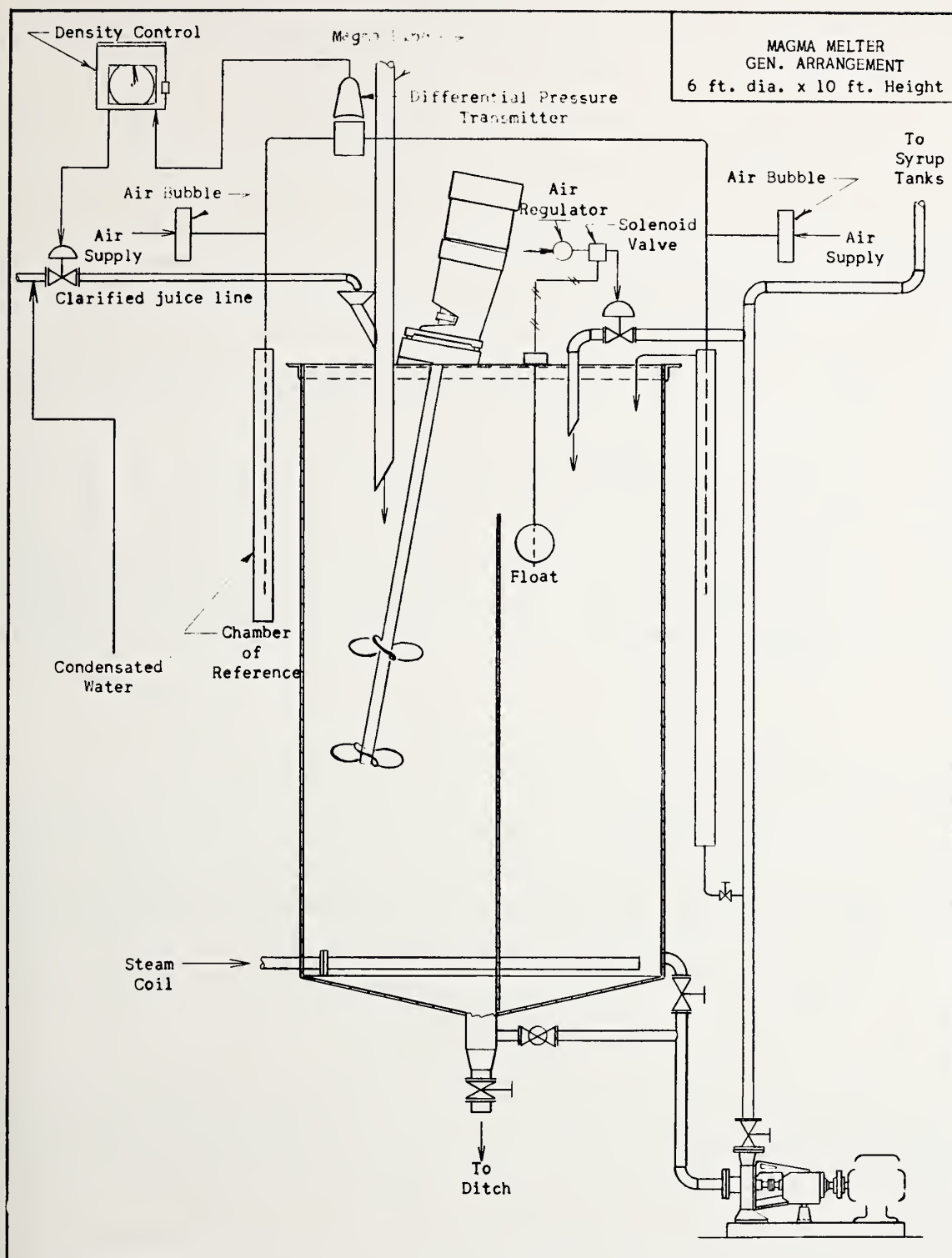


Fig. 1. Magma melter: general arrangement.

RESULTS

It is known that a considerable amount of impurities, especially mineral salts, become less soluble as the concentration of the juice progresses and part of these impurities deposit on the heating surface of the evaporator forming a hard scale, which must be removed periodically because they are poor conductors of heat.

Atlantic has 2 sets of evaporators, called A and B units, each composed of 4 bodies.

No expansion or enlargement has been made in our sets of evaporators for the past years and we were never able to prolong our cleaning periods for more than 4 days, maintaining our syrup concentration under normal figures and using the same exhaust steam pressure in our boiling house.

As soon as we started operating the magma melter on December 5, 1971, our evaporator was stopped for cleaning every 10 days, resulting in 150% more working time, and the 1st body that always has been used as a pre-evaporator started a cleaning period of every 18 days.

Nevertheless, on January 31, 1972, we decided to stop the excess of C magma from going to the melter and started sending it to the clarified juice tank through the evaporators, like it was before, in order to check the difference.

From the 2nd day of operation it was necessary to increase the steam pressure in our 1st 2 bodies in order to maintain the same figure in our syrup concentration, grinding at the same average and using the same imbibition % cane as before. Under these conditions we were forced to change our unit after 4 days of operation.

Our grinding rate has been increased from an average of 185 tons to 204 tons per hour during the last crop.

The syrup average concentration for the past year was 59.20 brix against 56.58 brix during the previous one, considering that the dilute juice brix average was 1 degree below during the past season.

For our cleaning we used the most common chemical products in the sugar industry, caustic soda and muriatic acid. The caustic soda used for the past harvest was 0.510 lb per ton of cane against 0.902 lb the previous season. The muriatic acid used in 1972 was 0.165 lb per ton of cane against 0.200 lb the year before.

CONCLUSIONS

Our basic advantage from the melter installation is the increase of the working period in the evaporator station from 4 to 10 days, which represents 150% more working time.

The quality of our commercial sugar has not been affected by the melting of our C sugar excess without passing through the evaporators system, as we have for the 1972 crop an ash content average of 3008 ppm in our A and B sugar, which is more or less the same average that we had for the 1971 crop.

Our final molasses exhaustion has been almost similar to the past crops; nevertheless, the last season is considered one of the worst in this part of the sugar process for the entire state of Florida because of the quality of the material we handled.

The ash content of our C sugar is 23,211 ppm, of which 616 ppm corresponds to sodium, 11,362 ppm to potassium and 11,233 ppm to calcium. This last element represents 50% of the total ash in our sugar magma, which we consider is a negative addition to our juice volume for the heat transmission of the evaporator's tubes, especially for the 1st bodies, where more than half the scale is generally calcium phosphate.

The sugarcane harvest is a race against killing freezes, and today many sugar houses are provided with more than one set of evaporators to avoid any lost time because of cleaning the heat transfer of the equipment. Nevertheless, it is of great economic importance to reduce the cleanings during the season because this represents less losses because of changing and liquidating the equipment, less use of chemical products for this purpose and consequently, most important of all, less damage of the installations.

PERFORMANCE OF THE SCREW PRESS AT CORA-TEXAS SUGAR FACTORY
WHITE CASTLE, LOUISIANA

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ABSTRACT

In order to increase the milling efficiency of the milling tandem, Cora-Texas installed a K-70 model, high pressure screw press from French-Oil Mill Machinery Co., of Piqua, Ohio, U.S.A. The milling tandem consists of 2 sets of revolving knives and 4-37" x 72" 3-roll mills. The press performance reduced the polarization in bagasse from 3.5 to 2.3 with an increase in sugar recovery of more than 7 lb per ton of cane and more than 1 gal of final molasses per ton of cane. The moisture in bagasse was reduced from 52 to 49%. The combustion characteristics of the bagasse, under all weather conditions, improved tremendously. Cora-Texas was able, for the first time, to burn all of the bagasse without any problem. Management and operating personnel are greatly pleased with the results and performance of the screw press. The lost time due to the press was 0.49% of the total time for the crop.

In early 1969 the Board at Cora-Texas decided it had to increase the milling efficiency of their milling tandem while at the same time attaining higher grinding rates. The tandem consists of 4-37" x 72" 3-roll mills preceded by two sets of cane knives. The addition of a 5th mill was considered, and a diffusing unit came into discussion with a representative firm. However, F. C. Schaffer and Associates, of Baton Rouge, Louisiana presented a study recommending the Screw Press as the best choice for Cora-Texas, backed up by their experience in engineering work in Florida. A pay-back of 3 years was predicted by this firm, assuming 140,000 tons cane per crop. The Board looked upon this report with particular interest and sent their Chief Engineer to Florida to have a close look at the mills which have screw presses there. The result was the order of a K-70 Model, High Pressure Screw Press from French-Oil Mill Machinery Co. of Piqua, Ohio, U.S.A. As a matter of record it should be stated that this press was to be the first unit of its kind installed in Louisiana, to handle all the bagasse from a milling tandem. St. Mary had previously installed a small press to handle cush-cush.

THE MODEL K-70 BAGASSE SCREW PRESS AND DRIVE

The press is driven by a 1500 hp, 3-stage Terry steam turbine with 2 hand valves, nominal speed 4000 rpm, with steam conditions at 125 psig, saturated, and 15 psig back pressure, through a high speed gear reducer with flexible couplings, all mounted on sole plate as a unit, with an output shaft speed of 1200 - 1800 rpm, for direct flexible coupling connection to the extended input drive shaft of the triple reduction gear driving the press. A 150 hp, 900 rpm standard foot mounted motor, TEFC, 3 phase, 60 cycle, 440 volt, drives the fast turning feed worm through a single reduction silent chain drive built into and completely enclosed in the integral gear reducer, with drive motor mounted on top of gear case. The press is equipped with a hydraulically controlled, instantly variable non-rotating orifice cone discharge mechanism with inner drainage. The cone is automatically positioned to maintain desired turbine load. Four short worms mounted on the main pressing shaft do the pressing. The speed of these worms varies between 50 and 80 rpm, according to the speed of the turbine.

BAGASSE AND STEAM GENERATION

Prior to the introduction of the press, Cora-Texas was a 3000 tons of cane per day sugar factory, with 3.5 - 4.0% pol and 52 - 54% moisture in bagasse. The combustion of this bagasse, particularly under bad weather conditions with mud and shucks, was invariably poor, despite the two 100,000 lb/hr Bigelow boilers with Dennis-Detrick cells plus one old 800 bhp B&W boiler (Stirling) with horse-shoe furnaces. It was very difficult at times to approach the boiler room without a good pair of goggles. The flames and smoke coming out of the furnaces kept a rather high temperature around this area, and when the wind blew from the east, the mill tandem and boiling house filled with smoke. Evaporator and filter operators were forced, at times, to wear goggles. The excess bagasse disposal and handling system became inadequate under such adverse conditions. Although the clarification and filtration stations normally became overloaded when this happened, it is safe to say that the boilers received the worst part. The gas consumption increased while the bagasse was being disposed of. The efficiency of the boilers while burning this kind of bagasse dropped drastically.

The press started operation on the first day of grinding, 1/2 hr after the crop officially started. A notable difference in the combustion of bagasse was noticed. The bad weather came immediately thereafter, with 1-1/4" rain on the second day of grinding, but the boilers never failed to burn all the bagasse readily, and the firemen never had it so easy at Cora-Texas. At the end of the crop, when the factory could run only during the day time due to excessive rain, the boilers did not experience any

difficulty in their combustion. The excess bagasse blower remained idle throughout the crop. The gas burned per ton cane increased substantially, not only due to the higher steam load and relatively slow grinding rate but also to a very high lost time due to lack of cane. No clinkers were seen in the furnaces this past crop. It was apparent that the press not only was reducing the moisture and sucrose content of the bagasse, but it was washing away some of the mud while preparing the bagasse for good combustion in the furnaces. It should be remembered that none of the boilers at Cora-Texas have air pre-heaters. The boiler room became the coolest place of the factory, especially when the wind was blowing from the east.

JUICE PROCESSING

The other aspect of interest, of course, is the effect of the press on the fabrication department. If the mud in the bagasse was reduced due to the "washing effect" in the press, then it had to go to the clarifiers. However, our mud was very well coagulated most of the season, even at times when our neighbors were having trouble settling it, and our clarified juice always showed the bright streak typical of Louisiana juices. Maybe the lower brix in dilute juice due to higher maceration helped to achieve a better settling. We did have some trouble at the beginning of the crop with our B strikes, but we were grinding very poor quality cane with plenty of shucks. Syrup purities at the beginning were around 72. As soon as the weather and cane conditions improved, the gums disappeared. We noticed that the grain in our B strikes failed to grow as other years, although no gums could be felt. We ended our crop with 97.0 pol in sugar, while last year we had 97.6. However, a check with Godchaux Sugar Refinery indicated that they were "catching hell", not only with our sugar, but with sugar from other mills as well. The manager thinks that this was due to the particular condition of the cane this year, probably accentuated by the storm just before grinding.

LABORATORY CONTROL

Cora-Texas does not have a dilute juice scale or a flowmeter. A maceration water meter, with recorder, was installed just before the crop. All the maceration water, at about 170 - 180 F, was applied to the twin screw conveyor feeding the press. The juice from the press was all pumped ahead of the last mill and the compound maceration continued, with the juice from the first 2 mills going to process. The remaceration pumps had insufficient capacity to handle the remaceration juices. The juice from the 4th mill overflowed all the time into No. 3 mill compartment and this ran into the dilute juice compartment throughout the entire crop. The daily manufacturing report is calculated under 2 main assumptions, which are just that, assumptions:

1. Dilution % normal juice equals maceration % cane.
2. Normal juice extraction such that a fiber % cane between 14 and 16 is obtained, depending on cane conditions.

Before the most important data of the manufacturing reports for 1970 and 1971 are posted here for comparison, it is necessary to establish that about 40% of the sugar production for this past crop is still in the warehouse. However, the belt sugar scale was set to read low, exactly the same percentage as the 1970 crop. After all the sugar from the 1970 crop was sold, 366,904 additional pounds were found. We expect, of course, to have a close repetition of that case. This year, however, the figures shown here for the 1971 crop still correspond to the scale reading as such, and the ones for 1970 correspond to the correct, actual figures after all the sugar and molasses were shipped.

Manufacturing Data

	1970 crop (without the press)	1971 crop (with the press)
Day crop started	Oct. 16	Oct. 15
Day crop ended	Dec. 4	Dec. 4
Loss time % total time,		
Mechanical	3.63	3.11
Press	--	0.49
Out of cane	6.43	13.38
Total	10.06	16.98
Gross tons cane ground	132,369.69	126,436.80
Gross tons cane ground per hour	123.88	125.45
Trash % gross cane	10.07	8.05
Converted (std.) tons % gross cane	92.26	93.84
Factory normal juice		
Brix	16.07	15.76
Pol	12.24	12.15
Purity	76.18	77.10

Manufacturing Data (Continued)

	1970 crop (without the press)	1971 crop (with the press)
Dilute juice, brix	12.26	11.44
Evaporator syrup, purity	79.87	79.05
Bagasse, pol	3.42	2.37
Moisture	51.99	48.99
Fiber	43.36	47.36
Pol in bagasse % fiber in bagasse	7.89	5.00
Fiber % gross cane	16.57	15.09
Pol % gross cane	9.98	10.09
Maceration % gross cane (Dilution % normal juice)	31.06	37.72
Maceration % gross cane added at press	--	28.32
Normal juice extraction	70.81	76.88
Dilute juice % gross cane	92.84	105.86
Pol extracted % pol in gross cane	86.91	92.52
Pol lost in bagasse % gross cane	1.31	0.75
Residual (or press) juice,		
Brix	7.25	3.15
Purity	73.52	64.76
Raw sugar produced (as made), lb.	19,291.640	20,648.064 (unofficial)
Pol of sugar	97.59 (Cora-Texas)	97.03
	97.25 (Refinery)	?
Total sugar, raw value, per gross ton cane	148.9	166.3 (unofficial)
Total sugar, raw value, per net ton cane	165.6	180.9
Total sugar, raw value, per converted (std.) ton cane	161.4	177.2 (unofficial)
Final molasses, purity	31.29	31.73
Gals. @ 80 bx/t.c. gross	6.04	7.55 (unofficial)
Press cake, pol	3.75	3.05
BHEN (ESG)	93.00	95.35
A and B strikes, total cu ft per		
T.C. gross	3.15	3.49
Lb. raw sugar (as made) per cu ft of		
A and B massecuite	46.21	46.78 (unofficial)
C strikes, cu ft per T.C. gross	1.05	1.30
solids in C sugar % solids in C massecuite	41.31	40.74 (unofficial)

OPERATIONAL COMMENTS

The total lost time charged to the press was 6 hr for the entire crop. This included 3-1/2 hr for changing the end worm, 30 days after the crop had started. The remaining time was mostly attributed to the tripping device of the steam turbine. Pol in bagasse at the beginning of the crop between 1.6 and 1.8% was obtained, with some grab samples of 1.2 - 1.4%. Moisture in bagasse of 47% was recorded at times in the early part of the crop. Purity of the press juice at the beginning was as low as 53.0. The good condition of the mills and press, the very slow grinding rate due to lack of cane, the low purity of the cane juices, and maceration water applied of the order of 45 - 50% on cane, all accounted for this. The power developed by the turbine, as calculated from the ring pressure, speed, and Willan's lines of the turbine, was around 600 hp. This represents about 30 hp/ton fiber/hr. The screw press was mostly turning at the lowest speed range, with the hydraulic pressure on the cone around 1500 psig. Retention time of bagasse in the pressing screws is about 15 sec as compared to about 2 sec in a 3-roll mill. Since the pressure on the bagasse is applied continuously and in an increasing manner, there is no reabsorption of the juice. Hot maceration water in sufficient quantity has to be provided to the press to obtain the highest efficiencies. There were no means for splitting the press juice between the last 2 mills, nor for cooling it. Moisture in the last mill bagasse went up from 55% at the beginning of the crop to 64% at the end. We can roughly say that pol % fiber in the last mill bagasse was about twice as high as the press bagasse. By the end of the crop this ratio increased to 2.5. Since the press is compartmentized, consideration has been given to the possibility of doing a remaceration in the press itself, with the purpose of increasing its efficiency while reducing the percentage of maceration water. Maceration water could be added ahead of the last 2 worms and the residual juice obtained pumped to the feed (twin screw) conveyor of the press. The juice from the first 2 worms will then be sent ahead of the last mill, after cooling it down to 140 F in a heat exchanger. The idea is to rewet the bagasse halfway along the press in the same manner as is being done in the milling tandem. There is very little extraction when compressing relatively dry bagasse. Flexibility should be provided to allow the maceration water to be distributed as desired, in accordance with the results obtained regarding sucrose and moisture. For this unit to become an injection press, major modifications amounting to about \$50,000 will have to be realized.

The installation at Cora-Texas is interlocked in a way such that, when either of the following units trip: The motors of the twin screw conveyor feeding the press, the 150 hp motor driving the fast turning feed worm, or the steam turbine, the belt conveyor carrying the bagasse from the mill to the press will reverse its movement automatically, delivering the bagasse into the main bagasse carrier going to the boilers, which is the same carrier handling the bagasse discharged from the press. Simultaneously, the maceration water is automatically diverted to the milling tandem.

A magnet mounted on top of the bagasse belt conveyor going to the press is indispensable to protect the internal components of the press. We were rather surprised with the high amount of tramp iron passing through the mills.

Although Cora-Texas has a rather inefficient cane washing station, the wear on the press was relatively mild. Only the end worm seemed to be worn, but much less than expected. The worm that was removed after one month of operations will be built up with Stellite no. 1 at the sugar factory, at a cost of around \$800. The other worms will be slightly touched up too. So far, after one crop, it can be said that the maintenance cost on the press will approximately be \$3,000.

The cost of the screw press with all components, including the triple reduction gear, runs around \$300,000. The steam turbine and high speed reduction gear cost \$30,000. The Eriez magnet, belt conveyor, twin screw conveyor, and electrical equipment and controls amounted to \$18,000. The erection cost of the press and auxiliaries was \$10,000. The grand total installed cost of all equipment mentioned above was approximately \$360,000.

As additional information, the new replacement cost of the internal components of the press which are subject to wear--worms, drainage bars and nose cone--is approximately \$12,000.

Cora-Texas management is eminently pleased with the installation of the French Screw Press. Its performance exceeded the projections and guarantee. We expect better results in the 1972 crop.

ROTARY COIL HEAT EXCHANGER ELEMENT FOR CRYSTALLIZER

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ABSTRACT

A not so new but rugged heat exchanger suitable for crystallizers and with a much better than average ratio of cooling surface to operating volume is described. It requires a minimum of attention and lends itself well to continuous crystallizer systems, as well as in cooling 1st sugars with the objective of improving overall recovery. Its parallel cooling pattern keeps reproduction to a minimum and exhaustion of molasses at an optimum in a shorter cycle.

INTRODUCTION

The sugar factory man is constantly on the search for equipment that has been designed to give optimum results but is at the same time relatively trouble free.

It is not easy to come by these demanding requirements in all the processing machinery utilized in the sugar factory. The efforts of all equipment designers certainly are directed towards achieving goals.

The rotary coil, parallel type heat exchanger meets these requirements. It is by no means new. Rather it appears that it has not been much publicized in this part of the country. It is rugged enough to work its way through the viscous massecuites of Hawaii and still perform a good mixing, cooling and heating job as the case might require.

THE EQUIPMENT

As you refer to the sketch (Fig. 1) you will notice that water is admitted through the drive end and by way of the hollow shaft feeds each coil in parallel for uniform temperature control. Built in chokes regulate the amount of water to each coil, and the coils discharge into the collecting header which runs along side the main shaft and empties through the hollow shaft at the tail end. The end of the main pipe shaft is compartmentized to keep the injection water from mixing with the outgoing water. The total water quantity flowing is controlled by a single valve on the discharge end and thus assures each coil of being full of flowing water at all times, be it cold or hot. The coils are made up in spirals, mounted helix fashion on the hollow shaft so that every cu ft of massecuite is swept through by a coil in each revolution. There are no dead zones which would have different temperatures or crystallization times to enhance production of various grain sizes. The coils are kept below the liquid or strike level to ensure maximum efficiency. The design is extremely rigid, and the coils are of seamless pipe to preclude the development of cracks with time due to metal fatigue from bending in ultra heavy strikes, such as those encountered in Hawaii.

The experience obtained in Hawaii with this crystallizer clearly indicates that one can probably cool a massecuite faster than one can produce a recoverable purity drop (esp. Hawaiian viscosities). Rapid stirring with complete intermeshing is of vital importance and this the rotary coil does well. While in Hawaii average speeds are around 1/3 rpm with their high ash and viscosities, 1/2 rpm would be a practical speed for other than high viscosity massecuites. Structurally the equipment can take it.

The shaft is usually 10" or 12" schedule 80 seamless steel pipe. The batter and support cross arms that go through the shaft as well as the return pipe are also schedule 80 seamless steel pipe. The rotary coils are made up of 2" schedule 40 seamless steel pipe. The heat exchanger is of all welded steel construction.

The coefficient of heat transfer is not lower than that of other pipe fabricated heat exchangers that run from 6-12 btu per sq ft per hr per °F depending on the type of massecuite being treated. The advantage is obtained in the extra surface carrying water that is in contact with the massecuite in constant motion.

The weight of the internals is about 30% more than the internals of the most common types. However, the cost per lb of finished crystallizer is very close to that of others which usually fall around .4 sq ft of heating surface per cu ft of strike. It is certainly a low cost investment that can save you factory space and at the same time improve the overall boiling house efficiency. Actually, in the final analysis the relative costs of crystallizers should be evaluated on the basis of heat exchanger area vs volume together with the efficiency with which the surface is utilized.

Many existing crystallizers can be converted readily to the Honiron crystallizer by simply replacing the internals between flanges with the rotary coil heat exchanger and thus obtain an improvement of at least 50% over the rotary arm and other similar types.

If there are several of these crystallizers, they can be interconnected for continuous operation in much the same way as is done to give a face lifting to the more common types.

In reheating, full advantage can be taken of its parallel flow to ensure no localized heat zones that would dissolve sucrose from the grain and so raise the final molasses purity and drop the recovery.

Coils are usually spaced to permit accessibility and still obtain about .65 sq ft of surface per cu ft of working massecuite. There are other types of cooling which are closer spaced, but these usually revolve in fixed disc planes and do not contact all the massecuite and depend upon conductivity. Then there are others more common in which only half the pipes are ever full of water and in which there is no predetermined flow path. In none of these is the cooling surface a comparable measure to the Honiron. The disc types, while capable of providing more cooling surface, do not produce the same massecuite mixing action, regardless of their positioning, and this mixing is most important when cooling rapidly especially if false grain is to be avoided. The Honiron coil system is easily checked for leaks at any time by merely closing the water outlet valve and placing it under full pressure. The fabrication man can appreciate a pressurized system not contributing to sucrose contamination of cooling waters when a leak develops (seamless pipe precludes the development of cracks).

A large California refiner utilizes these rotary coils in 3 rd remelts to cool them in 16 - 20 hr where previously they required twice as much time to get the same drop. The improvement is due to good mixing with double the ratio of exchanger surface to operating volume.

The rotary coil crystallizers are widely used in Hawaii and this type will be utilized exclusively at the Rio Grande Valley Sugar Growers' new Texas factory which is scheduled to begin operating in late 1973.

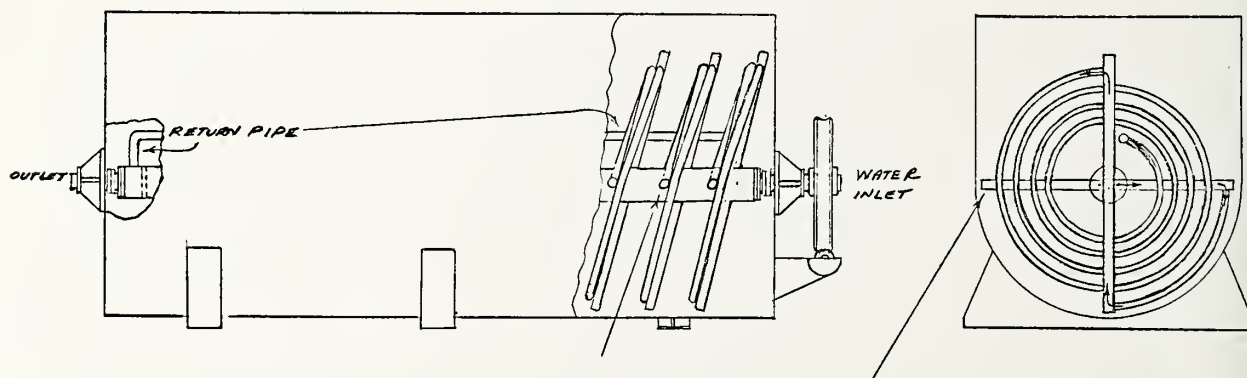


Fig. 1. Rotary coil heat exchanger element for crystallizer.

BOILER STACK EMISSION: CLEWISTON SUGAR HOUSE

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ABSTRACT

During the past 10 years, many changes were made in the Clewiston sugar house, including efforts to eliminate emission from boiler stacks. One of these efforts was the installation of a cyclonic wet scrubber. The author participated in the operation of the scrubber and the testing of its emission during its 1st year of operation. This paper deals with our earlier efforts to limit stack emission and with events leading up to the installation of the scrubber. The scrubber, its operation, and problems with its operation are described. Methods and results of emission sampling are presented. Since air pollution is becoming an ever-increasing problem with which all sugar mills are going to have to deal in the near future, the topics discussed in this paper are of vital concern to the sugar industry.

The Clewiston sugar house is located adjacent to the south side of Clewiston, Florida. During our cane grinding season, which usually lasts from the 1st of November until the middle of March, the winds prevail from the northeast. Therefore, most of our stack emissions are blown to the southwest. This area consist mostly of pastureland and Everglades, and is sparsely populated. It is only when the wind is from the south or southwest that people in town notice our smoke. This usually happens only when a cold front passes. When this happens at night and the wind and dew are just right, they get up in the morning and find their cars coated with a fine black charred bagacillo from our boilers. This is not thought to be a health hazard, but it is a nuisance which we are sure to hear and read about.

During the summer repair season of 1965, we installed our 1st stack emission control device on one of our boilers. It was an American Standard Series 361 fly ash collector, having 176 horizontal cyclone type tubes, arranged in a duct 22 tubes wide and 8 rows high. The fly ash collector was installed in the exhaust duct between the boiler and the induced draft fan. Because of an increased resistance in the duct, the fan diameter had to be increased. Two hoppers were provided under the collector, with rotary air lock valves to extract the dust. The dust was disposed of by being reinjected into the back of the boiler by a steam jet. A by-pass duct with a butterfly valve was provided over the collector, just in case it should become stopped up. The system cost about \$15,000 and was designed to collect 96% of all material over 44 microns, and 88% of all the fly ash in the gas. It had the side benefit of reducing wear on the I. D. fanwheel and air heater tubes, and also increased the boiler efficiency. Apparently the fly ash that was reinjected into the rear of the boiler was good fuel. At that time, we were operating 3 old Edge Moor boilers, generating 150 psi steam, and one Babcock-Wilcox boiler generating 600 psi steam. All of the boilers burned bagasse as primary fuel, but could be supplemented with oil.

The following year, we installed similar fly ash collectors in all of our boiler exhaust ducts.

In the summer of 1968, we installed 2 new Riley boilers to take the place of the 3 Edge Moor low pressure boilers in a plan for modernization and increased grinding rate. The same fly ash collectors used on the Edge Moor boilers were rebuilt, with the number of horizontal cyclone tubes being increased from 176 to 336, and installed on the new Riley boilers. The new boilers are rated at 150,000 lb of steam per hour and burn the bagasse partially in suspension rather than in cells like the old boilers. They are provided with vibrating grates and an ash sluicing system. The dust from the fly ash collectors is sluiced with water from the rotary valves to the ash hopper on the new boilers rather than being reinjected. It was thought that sand in the fly ash might cause excess wear on the boiler tubes if it were recirculated enough.

Starting January 1969, we were required by the state of Florida to sample and report the emissions from our stacks. The services of David B. Smith Engineers, Inc., consulting engineers, were obtained to help guide us in meeting the new requirements. Under their guidance, we purchased the needed sampling equipment and installed sampling ports in our boiler stacks. The sampling ports, consisting of 2 pipe nipples, 3-1/2" I. D. x 6" long, were installed at 90° from each other, at the 60-foot level of our 75-ft high stacks. Work platforms and caged access ladders were provided, all conforming to the Florida Industrial Commission safety standards.

On January 6, 1969, Mr. Specht of David B. Smith Engineers, Inc., arrived at the Clewiston sugar house and proceeded to instruct us in the procedure for taking the required samples. The same methods were used as are outlined in Western Precipitation Bulletin WP-50, which is the method adopted by the Florida Department of Air and Water Pollution Control.

Although the actual sampling time is only 30 min., it took us almost all of an 8-hour day to complete it. The equipment was carefully prepared, hoisted hand-over-hand to the platform where it was used then returned to the ground for careful measuring, weighing and cleaning. Two trips were required to the stack platform. The 1st to obtain data for calculating the rate for isokinetic sampling, and the 2nd to take the sample.

We dried the particulate sample overnight and weighed it after a cooling period. A calculating session was then in order, with the results giving stack gas particulate content, in grains per cu ft, and the total particulate emission of the boiler.

Two samples a month were obtained on each of our 3 boilers. Typical results on our high pressure boiler were about .15 grains per cu ft, with a total emission of 50 lbs per hour of dry particulate matter. It usually was producing 85,000 lb of steam per hour, burning bagasse for fuel. The 2 Riley low pressure boilers were normally operated at 175,000 - 190,000 lb of steam per hour and had a stack emission of about 1.5 grains per cu ft and a total emission of about 800 lbs per hour of dry particulate matter.

In 1970, air pollution was becoming a regular news topic. The Florida Department of Air and Water Pollution Control required testing and issued permits for the operation of boilers. The sugar mills were advised that they would have to take some definite steps to eliminate this source of air pollution. The Florida Sugar Cane League, consisting of all of the sugar mills, decided to search for a solution to this problem. This had many advantages over each mill going off on its own to find a solution.

One of the projects undertaken by the Florida Sugar Cane League was the installation of a pilot plant scrubber at the Clewiston sugar house. During the summer repair season, prior to the 1970-71 grinding season, a 16" pipe return bend was installed in the 87" dia. no. 1 boiler stack, just above the point where isokinetic sampling had normally been taken. A 12" square duct was attached, leading down to about 20 ft above the ground and curved out from the stack. When operation of the boiler began in November of 1970, smoke came from this duct and drifted through the boiler room, irritating the workers. A plate and gasket were installed over the end of the duct as a temporary remedy. When the pilot plant arrived in January, the end of the duct was uncovered and found to be completely filled with moist and packed sand and bagasse. It was necessary to install a clean-out port at the bend in the duct, and 2 men spent most of a day beating on the duct and probing at its contents to open it again.

The pilot plant, which had been rented from Linder Industrial Machinery Co. of Lakeland, Florida, was called a Mikro/Airetron scrubber. It was a vertical cylindrical cyclone, 39" dia. and 11 ft 3 in. high. The 9" x 12" inlet was 5 ft above the bottom and tangent to the righthand side. The 12" dia. outlet was at the top, tangent to the same side. A duct led from the outlet through an adjustable damper to a fan. The fan had a capacity of 2500 cfm and was equipped with a 12" dia. exhaust stack, 11 ft high. The stack contained thermometer and sampling ports. Above the entry duct to the cyclone were 4 thimbles, each containing 3 spray nozzles. Below the entry duct was a 250 gal reservoir. The pilot plant was furnished with 2 pumps. One was for pumping water through the spray nozzles, and the other was for pumping from the bottom of the cyclone. To facilitate recycling the water, screens were provided to remove solid material. Water from the screens drained to a reservoir supplying the spray pump. Three different screens were provided for their evaluation. They were: The "Dorr-Oliver" DSM screen, the "Link-Belt" vibrating screen, and the "Wemco" rotating screen. All 3 were capable of being equipped with automatic-self-cleaning devices, but for the pilot plant were equipped for manually operated self-cleaning. Make-up water for the pilot plant scrubber was provided to the spray pump reservoir and was controlled by a float valve. A totalizing meter was installed in the make-up water line. (See Fig. 1).

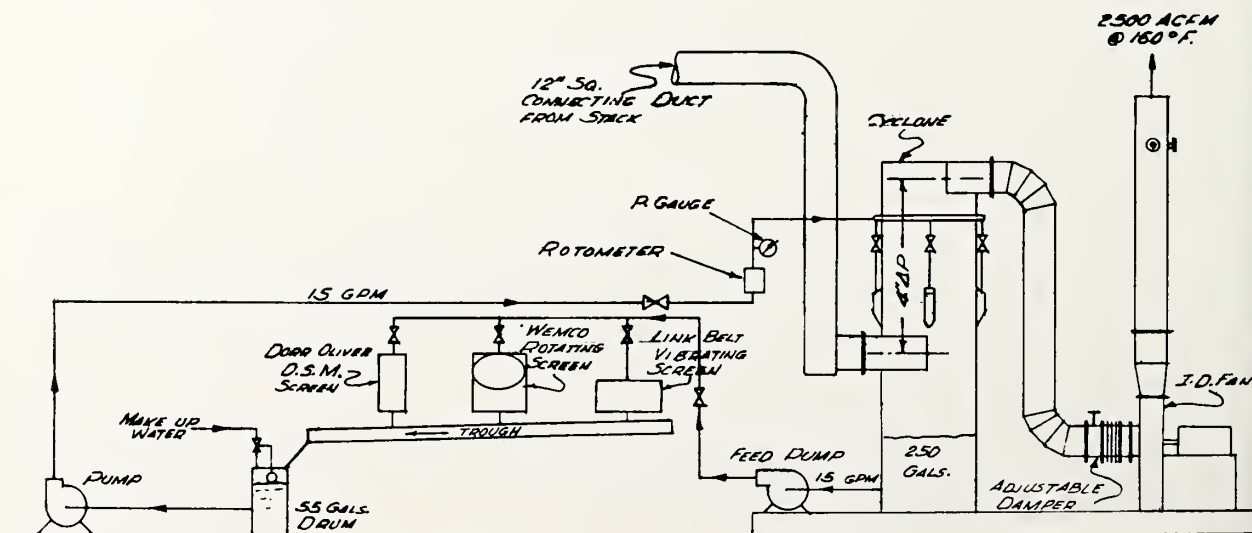


Fig. 1. Pilot plant scrubber arrangement.

After installation of all the equipment and after the duct from the boiler stack had been opened again, operation of the scrubber was begun. Much attention was given to the testing of the 3 types of screens furnished. All came with 40-, 60- and 100-mesh screens. It did not take long to determine that the finest screens did the best job and that screening the liquor from the scrubber was going to be an important part of a full size scrubber. All 3 screens were attached to a manifold, and switching from one to the other could be done in a few seconds.

Dilip Parikh, an engineer from MikroPul Company, arrived in Clewiston on January 13, 1970, and we began a series of emission tests. The fan damper was adjusted to give a drop across the cyclone of about 4" of water, and the nozzle pressure was adjusted to 40 psi. It was determined from nozzle charts that the flow rate was 19 gpm.

When the results of the 1st test were calculated, the results were disappointing. An inspection of the scrubber revealed that all of the spray nozzles had become plugged with bagasse, except 3 on 1 thimble. On all succeeding tests, all spray nozzles were checked just before the test was run. Results were much better, and when compared with full stack volume, yielded about 20 lb per hour emission, as compared to 800 lb per hour on the actual stack.

After 1 month of continuous operation the results had gradually increased to 240 lb per hour emission from the scrubber. It was found that the spray nozzles had become worn out. More water was being sprayed into the cyclone than could be handled by the recycle pump, and the balance was being blown out the stack, carrying suspended solid particles with it. The pump packing had begun to leak a lot, and had to be replaced about every 2 days. It was assumed that suspended carbon particles in the recycled liquor were very abrasive and were rapidly wearing out the pumps and nozzles.

A new set of nozzles was installed in the pilot plant scrubber on February 25, 1970, and the resulting test was better than ever, with a particulate emission rate of 4.6 lb per hour.

The nozzle wear problem could be a serious problem, so several drums of scrubber liquor were saved for experimenting during the summer repair season. Tungsten carbide inserted nozzles were obtained and mounted on a thimble along with Monel nozzles, that had been used before. The liquor that we had saved was agitated and circulated through these nozzles continuously for several weeks, with very little wear in any of the nozzles. It was concluded that the abrasive particles in the liquor had become worn smooth and were no longer abrasive.

As a result of the pilot plant scrubber operation, The US Sugar Corp. decided to install a full size Mikro/Airetron cyclonic scrubber on one of their low pressure boiler stacks at the Clewiston sugar house. The Florida Sugar Cane League agreed to pay for the scrubber if, after testing, the Florida Department of Air and Water Pollution Control would not accept it as a solution to the stack emission problem. (See Fig. 2).

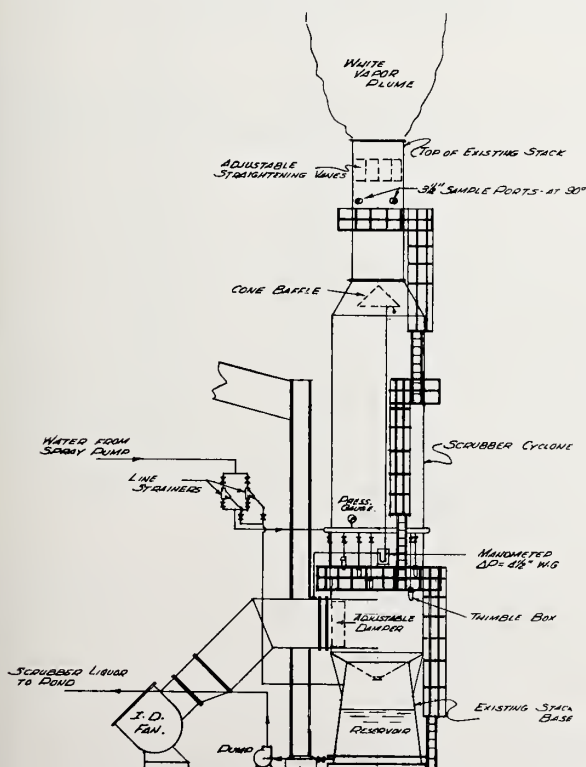


Fig. 2. Micro-airetron cyclonic scrubber.

During the summer repair season of 1971, plans and preparations were made for the installation of the full size scrubber, with much thought being given to the problems experienced with the pilot plant. It was decided that, instead of screening the liquor and recirculating it from a tank, a settling pond would be used. A settling pond had already been provided for the ash sluicing system of the boilers, and the water used in this could provide part of the make-up for the scrubber. This pond is located about 700 ft south of the boiler stacks and consists of 3 channels, 40 ft wide and 750 ft long, with spoil banks between them. This arrangement is convenient for dredging. These channels run east and west. The scrubber liquor was piped to the west end of the 1st channel, and the ash sluicing was piped to the 2nd channel, with the scrubber spray pump being installed in the 3rd channel. The east ends of all 3 channels were connected with culverts and spillways, arranged so that floating and settling material was held back, and water in between would pass. The height of the opening could be adjusted by adding or taking out boards. Piping from the scrubber to the pond had to be routed through, around and between buildings and about 1100 ft of pipe were required for each line. An 8" line was laid from the scrubber to the pond, and a 10" line was laid from the pond back to the scrubber. These lines are large enough for 2 scrubbers, in case we decide to add another later. A make-up line, with check valve, was installed to a nearby drainage canal. It was arranged so the settling pond water could be blocked from the pump suction and water could be supplied directly from the canal by gravity.

A 2-stage vertical turbine pump was installed at the end of the settling pond to furnish spray water for the scrubber. It had a rated capacity of 1100 gpm at 208 ft head, and was driven by a 75 hp motor. This required the installation of a power line from the mill and a transformer station near the pump. A control line was installed so the pump could be stopped and started from the boiler control panel.

A rubber-lined pump was installed at the scrubber to pump the liquor to the pond. This pump is an end-suction centrifugal type, with a rated capacity of 800 gpm at 112 ft head and is belt driven by a 40 hp motor. It also can be stopped and started from the boiler control panel. Both pump switches are furnished with indicator lights.

The scrubber cyclone is 12 ft 6 in. dia. and 55 ft 3 in. high, having a cone shaped bottom and top. The entrance is rectangular to fit existing fan ducts and is located tangential to the right hand side of the cyclone, near the bottom. It is equipped with an adjustable damper for increasing the speed of gases entering the cyclone. The outlet is located at the top center and is 7 ft 3 in. dia., to match the existing boiler stack. A cone-shaped baffle is mounted under the cyclone exit, and adjustable spin vanes are installed in the stack above. The cyclone, mounted on the existing stack base, utilizes the 1st 14 ft of the existing stack as a base and as a reservoir for the liquor pump. The top 19 ft 4 in. of the existing stack were mounted on top of the cyclone, making the overall height of the scrubber 86".

As in the pilot plant, spray nozzles are mounted above the entrance. There are a total of 96 spray nozzles, mounted on 16 thimbles, which are arranged in a staggered pattern, evenly spaced around the cyclone. The thimbles are mounted in recessed boxes and are attached to an overhead manifold by a rubber hose. Each thimble can be shut off and removed from the scrubber while it is in operation. A platform is provided around the scrubber at the nozzle level. Sampling nozzles are installed 9 ft from the top of the stack, and a platform is provided for them, as on the other boiler stacks. Caged access ladders and an intermediate rest platform are provided.

The spray-water line contains 2 line strainers, which are arranged in parallel so they can be back-flushed into the liquor reservoir tank so that either can be used. The valves for these strainers are also used to throttle the water, thereby controlling the nozzle header pressure. The total cost of the scrubber installation was approximately \$150,000.

When cane grinding commenced on November 9, 1971, everything for the scrubber had been installed, except the transformers for the spray pump, which had not arrived. They arrived and were installed about a month later. In the meantime, the boiler was operated normally, and the reservoir, at the bottom of the scrubber, was filled with wet bagasse and sand. A hinged plate had been provided to cover the opening from the cone bottom to this reservoir, by pulling a chain from the outside, but evidently it did not fit tightly enough. After cleaning the reservoir, we began circulating water through the scrubber and watched our dark smoke plume turn white. It looked good and everyone was enthused. The pumping system worked well and was giving no apparent trouble. The system was watched carefully, with samples of the scrubber liquor and spray water being taken daily. The scrubber liquor temperature held constant, at 160 F., just as it did in the pilot plant. The return spray water stayed near 90 F. Sediment from the black scrubber liquor remained at 2 - 3%, with the spray water staying almost clean and having only a trace of sediment. The pH of the spray water was taken daily and remained close to 7. It reached a low of 5 during the Christmas holiday, when the boiler was run on oil for 2 days in succession.

On December 12, 1971, the 1st particulate sample was collected, and results showed an emission of 28.74 lb per hour. The next 4 samples, taken during the next 10 days, showed an increasing emission rate. MikroPul engineer Dilip Parikh came to Clewiston to witness the 4th and 5th samples and was satisfied that they were reasonably accurate. The 5th sample showed an emission of 48.88 lb per hour and was more than twice the amount allowed by the State for the quantity of fuel burned.

An examination of the spray nozzles was then in order and showed the nozzles to be in bad shape. Most of the nozzles had been eroded through from the outside, on the upstream side of the cyclone. The thimbles were recessed, but not enough to protect the nozzles. While the scrubber was being operated, the thimbles were removed, one at a time and the holes in the top flange were slotted about 5/8" to

allow further recessing, to protect the nozzles. When a thimble was removed, hot water spewed from the opening, but a burlap bag stuffed into the hole proved to be an easy remedy. The nozzles showed very little signs of internal wear, and it was thought that the nozzles had been eroded by sand in the stack gases while the scrubber had been run dry during the 1st month of grinding.

A new set of nozzles was installed, and particulate emission sampling was resumed on January 2, 1972. In succeeding weeks, thimbles were removed several times for inspection, but only slight wear could be detected externally or internally. Occasionally a nozzle was found stopped up by a piece of bagasse.

At one time near the end of January, the spillway level in the pond was raised and water was diverted from the drainage canal to the spray pump. This water contained a lot of trash and caused the line strainers to become stopped up frequently. This only lasted for a few days and was remedied by switching back to pond water.

A table is enclosed with this report showing the results of all twenty-six samples taken from the scrubber. The best sample was on January 2, 1972, and was the 1st sample taken after the new nozzles were installed. It showed an emission of 15.42 lb per hour. The worst sample was taken on January 31, 1972, and showed an emission of 61.06 lb per hour. It was discovered during sampling that the line strainer had become plugged and the nozzle pressure had diminished to 15 psi. Even then the stackplume remained white and the emission was considerably less than the 700 - 800 lb per hour normally found on the stack without the scrubber. Throwing out the extreme high and the extreme low samples, the average, after the new nozzles were installed, was 29.69 lb per hour. This is about 2 lb more than was allowed by the State in 1970 for the amount of fuel burned and is about 6 lb per hour more than is allowed in the new 1972 administrative code. A mass plant emission limitation has been recommended by the State and, if this were enforced, would allot only 13.21 lb per hour to this boiler.

Table 1. Scrubber stack particulate emission tests, Clewiston sugar house.

Ref. No.	Date	Fuel Burned Lbs./Hr. (Dry Bagasse)	Steam Produced Lbs./Hr.	Stack Gas Flow S.C.F.M. Dry	Particulate Emission		
					Grains /cu.ft.	Actual Lbs./Hr.	Allowable Lbs./Hr.
1-S	12-12-71	39,100	200,000	74,700	.0340	28.74	22.6
2-S	12-14-71	42,200	215,000	69,300	.0316	24.81	23.8
3-S	12-16-71	39,100	200,000	69,400	.0576	45.28	22.6
4-S	12-21-71	39,100	200,000	63,100	.0522	37.31	22.6
5-S	12-22-71	39,100	200,000	58,500	.0679	48.88	22.6
NOTE: It was discovered at this point that most of the spray nozzles were eroded through from the outside. The nozzles were replaced before further testing.							
6-S	1-2-72	35,400	180,000	59,500	.0216	15.42	21.4
7-S	1-4-72	35,400	180,000	50,400	.0443	31.62	21.4
8-S	1-6-72	37,300	190,000	55,300	.0429	29.04	22.0
9-S	1-9-72	31,300	160,000	62,750	.0440	31.60	19.8
10-S	1-11-72	16,600 & 4,000 lbs. Oil	150,000	71,100	.0306	23.29	20.8
11-S	1-13-72	32,400 & 1,246 lbs. Oil	185,000	60,700	.0364	27.05	22.5
12-S	1-16-72	37,300 & 1,200 lbs. Oil	210,000	61,500	.0407	30.31	24.2
13-S	1-19-72	35,000 & 1,308 lbs. oil	200,000	66,300	.0376	29.68	23.6
14-S	1-20-72	34,800 & 1,370 lbs. oil	200,000	64,600	.0306	24.15	23.6
15-S	1-26-72	37,210	190,000	64,820	.0454	35.65	22.0
16-S	1-31-72	39,168	200,000	69,600	.0703	61.06	22.8
17-S	2-8-72	32,000 & 1,200 lbs. oil	175,000	64,776	.0645	35.93	22.3
18-S	2-12-72	28,200 & 1,300 lbs. oil	165,000	51,461	.0394	* 22.36	21.0
19-S	2-13-72	27,200 & 1,600 lbs. oil	165,000	45,945	.0782	40.13	21.1
20-S	2-14-72	32,400	165,000	55,374	.0434	28.12	20.2
21-S	2-15-72	28,500 & 1,200 lbs. oil	165,000	59,027	.0468	* 31.02	21.0
22-S	2-15-72	28,500 & 1,200 lbs. oil	165,000	54,824	.0330	20.12	21.0
23-S	2-16-72	32,314	165,000	57,868	.0555	* 36.39	20.2
24-S	2-20-72	30,400	155,000	54,983	.0444	* 23.64	19.4
25-S	2-21-72	31,400	160,000	51,543	.0493	* 29.02	19.8
26-S	2-26-72	31,400	160,000	49,114	.0593	* 35.08	19.8

NOTE: Based on mass emission limitations as is proposed in "Chapter 17-2 Florida Administrative Code", the average allowable emission for the Scrubber during the month of December, 1971 would have been 13.21 lbs./hr., the boiler having averaged 200,000 lbs. Steam per hour for this period

* Steam nozzles turned on in duct to scrubber.

In an effort to improve scrubber performance, steam and condensate water pipes were installed in the duct leading from the induced draft fan to the scrubber. It was thought that if the smaller particles in the gases could be wetted before reaching the scrubber, that the efficiency would be improved. No significant improvement could be found in our tests, however.

On February 10, 1972, the fan wheel on the I. D. fan came apart. One rim of the wheel and the attached blades wiped out the steam and water pipes and lodged in the damper, at the entrance to the scrubber.

The damage was repaired, and the inside of the scrubber was inspected. It was suspected that the same abrasion that had eroded the nozzles earlier may have done the same to the inside of the cyclone. The entry to the cyclone had been lined with stainless steel plate, and no significant wear could be detected. Inspection of the fan turbine rotor showed the buckets to be loose and it was decided to finish the crop with an electric motor driving the I. D. fan. The motor did not have the power and speed that the turbine had, so the boiler capacity and scrubber back pressure were both reduced. Plans to increase the scrubber pressure drop, for further sampling, were scrubbed.

The scrubber had been designed to operate at 4-1/2" of water differential pressure, with 50 psi on the nozzles. This would require 785 gpm of water. Most of the samples were taken at the designed pressures; however, the water pressure was increased to 75 psi for the 15th sample on January 26. This sample showed higher than average emission. Three thimbles had been shut off, to keep the same water flow rate as when operating at 50 psi. On the 17th sample, on February 8, 1972, the same thing was done, with the additional increase of pressure differential to 5-1/2" of water. The results of this sample were also higher than average.

The scrubber plume appeared to be pure white most of the time and vanished a few hundred ft away from the stack. Since it was adjacent to other boiler stacks which were also emitting smoke, the residual smoke color from the scrubber could not be determined. On occasion, the plume was black for 1 or 2 minutes while excess oil was being burned. This usually happened when the boiler fire was smothered by wet bagasse and the operator had his oil burners wide open in an effort not to lose pressure. On a few occasions, when the boiler was run on oil only, nothing could be seen coming from the stack. Moisture from the burning bagasse was needed to show a white vapor plume.

Any time that it became necessary to shut off the pumps for more than 15 or 20 min., the reservoir at the bottom of the scrubber was opened and cleaned out with a fire hose. This job required a mechanic and 2 helpers and usually took about 1 or 2 hours, depending on how much fly ash had settled in the hopper. We did not want to take a chance on stopping up 1100 ft of pipe to the settling pond. Most of it was underground and had no clean-outs.

The surrounding area was spotted by droplets from carryover. This was not as bad as was seen from the pilot plant, and MikroPul engineers believe that it can be eliminated by the installation of a mist eliminator in the top of the scrubber cyclone. This would also call for steam pipes for cleaning the mist eliminator.

Plans are being made for further improvements to the scrubber in an effort to make it meet the State requirements. Plans are also being discussed for the installation of an impingement type scrubber on the adjacent boiler stack for comparison. We have been given until January 1, 1975, to find the solution and meet the State requirements.

AIR AND WATER ENVIRONMENTAL CONTROL
IN THE CANE SUGAR INDUSTRY

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ABSTRACT

This paper reviews the problems confronting the cane sugar industry in the area of environmental control. The industries' past problems are reviewed and tied into present and anticipated future problems. The basic research for the paper was done in Florida during 1968 and 1969 and in Louisiana during 1970 and 1971. The research demonstrates the seriousness of the problem and relates that the "state of the art" is such that ultimate wastes can be treated and released to the atmosphere, into streams and water bodies well within the requirements of the various regulatory agencies.

INTRODUCTION

Air and water pollution has become a national conversation topic. It is daily discussed in the news media. Marches, demonstrations, protests and high emotions accompany the subject throughout the US.

The sugar industry has already felt the pressures brought about by such actions. Every state in the union has revised, revamped, redesigned and submitted their implementation plans to federal authorities for approval during the past year. Many air quality control plans were recently rejected for various reasons, mostly because they weren't as specific or as strict as required.

It is reasonable that everyone should be concerned about their present and future well-being and the well-being of future generations. It is understandable that citizens are demanding that all forms of pollution be cleaned up and eliminated. It is logical that industrial leaders and politicians are concerned. But good sense and practicality must prevail. This is our responsibility as technically trained people. We must maintain the balance between desire and rationality.

This paper will present the groundwork for the technical approach to our responsibility.

DISCUSSION

During the harvesting of sugarcane and the processing of raw sugar, various materials inevitably became airborne or waterborne. These materials result in a temporary detrimental effect on the quality of the ambient air and the process water. Cane field spraying or dusting, fugitive dust from fields and unpaved areas, odors from processing, cane washing, wet weather during harvest, temporary factory upsets, and other conditions all contribute to the overall problem.

These problems in the cane sugar industry are considerably different than in many other industries in the US. The states of Hawaii, Louisiana and Florida have recognized this to some extent, but not in all cases. The greatest difference is the seasonal operation of the industry.

As early as 1954, Louisiana saw need to start regulating the waste water discharges from sugar factories. The problem of water pollution was not a new one to the sugar industry. Many of the raw sugar factories of today do not differ significantly in their operations from those of a quarter century ago. There is little question that the mills then discharged as much or more oxygen loadings than they do today.

Three factors have aggravated the waste disposal problem of the Louisiana mills to the extent that it received public attention at that time and still does. First, and most important, was the obstruction to flow in the bayous of Louisiana by flood control structures erected by the US engineers. Once proud waterways have been reduced to little more than tidal streams that flow upstream as often as downstream, depending upon the prevailing winds and tidal conditions. Due to this erratic flow a mill often finds waste that was discharged into one of these streams several days before has been carried back upstream again to the very back door of the factory. At other times the level of the water may drop until much of the stream bottom is exposed.

The 2nd factor causing the pollution difficulty encountered by the sugar mills was the increase in the practice of washing the cane entering the mills in order to remove loose dirt and trash. Machine methods of cane harvesting have increased the amount of foreign material brought in with the cane to the point that an increasing number of the raw sugar houses in Louisiana find it advantageous to wash their cane. The effluent from this cane washing operation has a high BOD, and is used in large quantities as can be noted in Tables 6 - 15. Because of its large volume and high BOD this effluent stream represents the chief waste water disposal problem confronting the Louisiana and Hawaiian sugar industry, and may eventually become a Florida problem.

The 3rd factor in this water pollution problem is the increased throughput of the average mill. This steady increase has not been accompanied by a corresponding enlargement of plant facilities. The consequence of this is that many of the mills are now operating at far greater capacities than they were designed to handle. The resulting overloading of equipment has caused the problems of spills and entrainment to become pollution problems. Recent increased quotas have brought this problem back to the front burner and great care should be taken by factories shooting for greater throughput during 1972 and 1973.

The factories in Florida do not have this serious problem at this time; however, they have been favored with an adequate labor force for hand harvesting which produces a much cleaner cane. There are indications at this time, however, that this situation is rapidly changing and mechanical harvesting is becoming imperative. Corresponding with this change are the recent increased pressures being brought about for air quality improvement. Directly in the line of fire is field burning and boiler stack control. The need for an effluent mechanical harvesting device that in one operation can cut, top, deleaf and load the cane cannot be over-emphasized.

Mechanical dust collectors have been common for many years in Florida and are increasing in popularity in other states. However, state and federal regulations are rapidly changing and the time is here when mechanical separation may not be the total answer; however, there has been some recent improvement in their design and efficiency.

Although tests conducted by the Florida Sugar Cane League, Inc. in 1967 and 1968 substantially proved that particulates released to the atmosphere by field burning and boiler stacks are such that they are largely non-respirable, non-toxic and the majority of the weight of the particles returns to the farmers soil from whence it came, the source emissions are being enforced by local, state and federal agencies in greater numbers.

The same situation is prevailing in water quality control. 1971 saw the beginning of a national inventory of industrial pollutants. The Environmental Protection Agency (EPA) through the Corps of Engineers required all industries discharging to navigatable waters to submit quantitative and qualitative analyses of their discharges. The EPA then requested the same information from those industries impounding their wastes. After the digestion of this massive amount of data, the EPA should be able to provide much more intelligent guidance to problem solution than any effort prior to this time. However, their success will depend largely on whether the data accumulated is used scientifically or emotionally. We hope and believe at this time that it will be scientifically.

How does this all affect the sugar industry? First, the sugar industry, because of its short operating period of 2 - 6 months, cannot afford the elaborate treatment facilities of other industries. This fact has not been recognized in some circles. However, the sugar industry is favored in that almost all of its waterborne wastes are bio-degradable, which provides a very economical method of disposal when compared to the problems of other industries. It is also favored in that the boilers burning bagasse emit very low amounts of SO₂ and NO₂, which are difficult to remove, a large amount of their emissions are particulates as shown in Table 1-5 which can be removed by conventional "state of the art" methods.

How does one know what he has to do to control his emissions and what equipment to install. This is just like knowing what purity your juice is running; you analyze for it. The methods are not standard and the equipment is expensive and it takes a highly skilled operator, but these resources are available through a few qualified consultants. They can save you valuable time and money because they are experts in their field and are trained to analyze the effluent and design equipment to install to do the proper job. Don't ask them to analyze the purity of your juice because they would be just as lost there as you would be analyzing the stack effluent or waste water.

Table 1. Stack analyses of emissions from boilers 1, 2, and 3.

Parameter	Run no.		Average
	1	2	
Date	11-12-71	11-12-71	
Stack flow rate - SCFM, dry	53,419	53,442	53,430
% water vapor -- % vol.	7	7	7
% CO ₂ -- vol % dry	8.6	8.6	8.6
% O ₂ -- vol % dry	9.4	9.4	9.4
% excess air at sampling point	75.6	75.6	75.6
Particulates, probe, cyclone and filter catch			
gr/SCF dry, 70 F, 29.92" Hg	0.733	1.205	0.969
gr/CF at stack conditions	0.398	0.654	0.526
lb/hr	335.7	551.8	443.8
Particulates, total catch			
gr/SCF dry, 70 F, 29.92" Hg	0.810	1.276	1.043
gr/CF at stack conditions	0.439	0.692	0.566
lb/hr	371.0	584.4	477.7

Table 2. Stack analyses of emissions from boiler no. 4.

Parameter	Analyses
Date	11-12-71
Stack flow rate - SCFM, dry	28,718
% water vapor -- % vol.	2
% CO ₂ -- vol % dry	3.0
% O ₂ -- vol % dry	16.4
% excess air at sampling point	323.2
Particulates, probe, cyclone, and filter catch	
gr/SCF dry, 70 F, 29.92" Hg	1.984
gr/CF at stack conditions	1.233
lb/hr	488.5
Particulates, total catch	
gr/SCF dry, 70 F, 29.92" Hg	2.045
gr/CF at stack conditions	1.270
lb/hr	503.3

Table 3. Stack analyses of emissions from boiler no. 5.

Parameter	Analyses
Date	11-10-71
Stack flow rate -- SCFM, dry	20,922
% water vapor -- % vol.	6
% CO ₂ -- vol % dry	7.0
% O ₂ -- vol % dry	12.2
% excess air at sampling point	130.0
Particulates, probe, cyclone, and filter catch	
gr/SCF dry, 70 F, 29.92" Hg	0.450
gr/CF at stack conditions	0.218
lb/hr	80.8
Particulates, total catch	
gr/SCF dry, 70 F, 29.92" Hg	0.489
gr/CF at stack conditions	0.236
lb/hr	87.6

Table 4. Particle size distributions, Martin's diameter

Size, um	Boiler no. 5		Boiler no. 1,2,3		Boiler no. 4	
	No. %	Wt. %	No. %	Wt. %	No. %	Wt. %
<2.2	9.02	0	16.0	0	7.40	0
2.2 - 4.4	17.0	0	20.6	0	18.5	0
4.4 - 8.8	24.5	0.06	25.5	0.05	27.2	0.08
8.8 - 17.6	24.5	0.55	15.4	0.24	22.2	0.54
17.6 - 35.2	17.0	3.08	13.5	1.71	15.1	2.96
35.2 - 70.4	5.41	7.88	5.53	5.62	6.34	9.97
70.4 - 140.8	1.80	21.0	1.84	15.0	2.64	33.2
140.8 - 220.0	0.36	20.9	1.23	49.8	0.26	16.6
>220.0	0.36	46.4	0.30	27.5	0.26	36.6

Table 5. Operational data.

Date	Tons cane ground	lb sugar made	Gal molasses made	Factory lost time, hr
11/8/71	1,650	326,950	10,408	4.00
11/9/71	1,970	261,292	12,273	0.00
11/10/71	500	159,468	2,417	21.00
11/11/71	870	135,400	2,121	13.00
11/12/71	2,050	314,370	10,761	0.00

In referring to Tables 1 - 5, the particulate emission on boilers 1, 2 and 3 was 1.043 grains per scf. This is considerably above the state standards where these boilers are located and all other state standards where cane is grown. They did not have mechanical dust collectors installed. Boilers no. 4 and 5 had fly ash arrestors installed and the particulates on no. 4 were higher than on no. 1, 2 and 3. This is quite common as the particle size of no. 4 was much smaller than on no. 1, 2 and 3. Quite typically boilers with fly ash arrestors and reinjection will have a higher emission load than boilers without them. Its just that the boilers without them let out bigger particles which are easier to see.

Tables 6 - 15 show water analyses for 3 different factories. Note that there is a large variance in flows, quantities of wastes and treatment requirements for each mill. Note also the oxygen demand on the discharge streams. All are very high and above the limits set down by the state in which they are operating. The problems can all be solved, however, by existing technology and without massive land areas and equipment and expenditures.

Table 6. Average of all chemical data.

Sample	pH	SS	DS	VS	TS	Alk	Color	COD	BOD	NO ₃	NH ₃	ON	TP	OP
1. Bayou upstream	6.90	152	128	120	280	185	10	41	5.9	0.438	0	0.973	4.219	2.887
2. Bayou downstream	6.97	153	165	110	318	186	15	36	7.4	0.194	0	1.247	0.957	0.376
3. Injection water	6.90	222	114	112	326	191	15	63	10.2	0.038	0	1.180	0.793	1.033
4. Hot well overflow	--	--	--	--	--	--	--	66	13.2	--	--	--	--	--
5. Cane wash water	6.94	128	196	126	324	--	10	56	11.7	--	--	--	--	--
15. Wash water out		1592	451	573	2043	--	--	808	222	--	--	--	--	--
6. Washwater to canal	4.79	376	422	334	734	69	15	936	246	0.084	0	4.326	2.492	2.814
7. 3rd effect barometric	--	--	--	--	--	--	--	796*	115	--	--	--	--	--
8a. #1 pan**	--	--	--	--	--	--	--	248	97.0	--	--	--	--	--
8b. #2 pan**	--	--	--	--	--	--	--	84	13.0	--	--	--	--	--
8c. #3 pan**	--	--	--	--	--	--	--	336	15.6	--	--	--	--	--
9. Filler barometric	--	--	--	--	--	--	--	141	7.0	--	--	--	--	--
10. Boiler blowdown	11.3	--	--	--	--	--	--	890	--	--	--	--	--	--
11. Mill floor wash	--	--	--	--	--	--	--	2302	713	--	--	--	--	--
12. Boiler house floorwash	--	--	--	--	--	--	--	760	165	--	--	--	--	--
13. Drainage ditch	7.07	202	486	434	654	170	10	569	342	0.077	0	2.425	1.111	.623
14. 18" line to bayou	6.96	135	212	162	364	184	10	102	45	0.039	0	1.482	.737	.266

*Highly variable--from 50 to 2540

**Highly variable

Note: All results as mg/l

Table 7. Physical description of intake water and discharge.

Parameter and (code)	Intake	Discharge to canal			Discharge to bayou		
	(total in- take water)	Average (daily)	Minimum (operating yr)	Maximum* (operating yr)	Average (daily)	Minimum (operating yr)	Maximum* (operating yr)
Flow MGD	9.24	1.92	0.00	2.00	6.29	0.00	9.0
pH	6.9	4.79	--	5.0	6.96	--	7.3
Temperature (winter) (°F)	68.6	88.8	--	90.0	98.5	--	102
Color units	15	15	--	15	10	--	10

*Estimated

Table 8. Characteristics of wastewater discharged to canal.

Parameter and code	Intake		Discharge			
	Intake water (daily average conc)	Intake water lb/day	Maximum* concentration	Maximum* lb per day	Daily ave conc	Average lb per day
Alkalinity (as CaCO ₃)	191	3056	118	1888	69	1104
BOD, 5-day	10.2	163	300	480	246	3936
COD	63	1008	960	15360	936	14976
Total solids	326	5216	1000	16000	734	11744
Total dissolved solids	114	1824	750	12000	422	6752
Total suspended solids	222	3552	700	11200	376	6016
Total volatile solids	112	1792	650	10400	334	5344
Ammonia (as NH ₃)	0	0	0	0	0	0
Kjeldahl nitrogen	1.180	18.88	4.5	72.0	4.33	69.28
Nitrate (as NO ₃)	0.038	.608	0.9	1.44	0.084	1.34
Phosphorus total (as PO ₄)	0.793	12.69	5.0	80	2.49	39.84
Orthophosphorus (as PO ₄)	1.033	16.5	5.0	80	2.81	44.96

Note: All concentrations as mg/l.

*Estimated.

Table 9. Characteristics of waste water discharged to bayou.

Parameter and code	Intake		Discharges			
	Intake water (daily average conc)	Treated Intake water lb/day	Maximum* Concentration	Maximum* lb per day	Daily Ave Conc	Average lb per day
Alkalinity (as CaCO ₃)	191	10066	200	11320	184	10423
BOD, 5-day	10.2	537.5	100	5660	45	2549
COD	63	3320	300	16980	102	5773
Total solids	326	17180	500	28300	364	20602
Total dissolved solids	114	6008	400	22640	212	11999
Total suspended solids	222	11700	250	14150	135	7641
Total volatile solids	112	5902	300	16980	162	9169
Ammonia (as NH ₃)	0	0	0	0	0	0
Kjeldahl nitrogen	1.180	62.2	2.0	113	1.48	83.8
Nitrate (as NO ₃)	0.038	2.0	0.05	2.8	0.039	2.2
Phosphorus total (as PO ₄)	0.793	41.8	1.0	56.6	.737	41.7
Orthophosphorus (as PO ₄)	1.033	54.4	1.0	56.6	.266	15.1

Note: All concentrations as mg/l.

*Estimated.

Table 10. Tabulation of flows calculated from flow meters and material balances.

Stream No.	Stream	Discharge pressure, psig	Differential pressure in. H ₂ O	Temp., °F	Flow, GPM	Flow, GPD	Flow lb/day (temp. corrected)
3.	#1 injection water	32	137.3	68.6	3290	4,738,080	39,445,644
3A.	#2 injection water	38	410.7	68.6	2430	3,499,680	29,129,540
3B.	#3 injection water	--	--	--	--	--	--
5.	Cane wash in	38.7	216.7	93	1175	1,692,000	14,032,256
6.	Cane wash to canal	224	89.3	88.8	1332	1,917,720	15,914,615
14.	18" to bayou	--	--	95.3	4716	6,791,520	56,304,827

Table 11. Averages of chemical data.

Sample	pH	SS	DS	VS	TS	Alk	Color	COD	BOD	NH ₃	ON	NO ₃	TP	OP	Temp., °F.
1. River up-stream	8.0	84	494		578	324	5	123		0.0	0.475	0.390	0.695	0.626	72
2. River down-stream	8.1	104	368		472	242	5	113	9.9	0.0	0.196	0.630	0.271	0.196	74
3. Cane wash in								43	20						96
4. Excess condensate								3425	2040						138.5
5. Hotwell overflow	7.83	44.7	305	106	481	552	5	377	179	0.0	1.420	0.015	0.509	0.313	100.8
6. Cane wash effluent	7.94	1568	348	493	1770	550	5	372	148	0.0	2.373	0.063	1.520	0.463	89.8
7a. #1 evaporator barometric								18	2						91.6
7b. #2 evaporator barometric								420	228						92.8
8a. #1 pan barometric								185	45.2						94.3
8b. #2 pan barometric								68	36						99.6
8c. #3 pan barometric								75	31						95.2
8d. #4 pan barometric								61	27						115.6
9. Filter barometric								77	33						101.7
10. Boiler blow-down	11.6				2300			147							200
12. Fly ash pond overflow								29	1.8						66
13. Discharge to river	7.41	106	417	148	523	524	5	412	204	0.0	1.313	0.016	2.063	1.728	93.8
14. Well water	8.10	24	454		478	582	5			0.0	0.494	0.012	0.195	0.163	67.8
15. Filter mud pond overflow								9214	8250						80.0
16. Fly ash pump discharge	7.0	166				520	5	5	3.1						

Data expressed as mg/l, except for pH.

Table 12. Physical description of intake water and discharge.

Parameter	Intake		Discharge	
	Intake water	Average (daily)	Minimum (operating year)	Maximum* (operating year)
Flow mgd	14.0	14.0	0	14.0
pH	8.10	7.41	-	7.3
Temperature (°F)	67.8	93.8	-	98
Color units	5	5	-	10

*Estimated

Table 13. Chemical description of intake water and discharge

Parameter	Intake		Discharge			
	Daily ave conc.	lb/day	Maximum* conc.	Maximum* lb/day	Daily ave conc.	Average lb/day
Alkalinity	582	68,000	532	62,000	524	61,000
BOD	-	-	300	35,000	204	24,000
COD	-	-	500	58,000	412	48,000
Total solids	478	56,000	750	88,000	523	61,000
Total dissolved solids	454	53,000	600	70,000	417	49,000
Total suspended solids	24	2,800	150	18,000	106	12,000
Total volatile solids	-	-	300	35,000	148	17,000
Ammonia	0	-	0	0	0	0
Kjeldahl nitrogen	0.494	58	1.8	210	1.313	150
Nitrate	0.012	1.4	0.03	3.5	0.016	1.9
Total phosphorus	0.195	23	2.6	300	2.063	240
Orthophosphorus	0.163	19	2.0	230	1.728	200
Total coliforms**	-	-	-	-	600000	-
Fecal coliforms**	-	-	-	-	13000	-

*Estimated

**Colonies per 100 ml

Note: All concentrations as mg/l.

Table 14. Tabulation of flows, calculated from pump curves and outfall methods.

Stream no.	Stream	Discharge pressure	Temperature (°F)	Flow, GPM	Flow, GPD	Flow #/day, temp, corrected
3	Cane wash in	13.5	98.5	5600	8,064,000	66,807,195
5	Hotwell overflow	--	102	3900	5,616,000	46,491,779
13A	North disc. to river	12	95	8650	12,456,000	103,265,597
13B	South disc. to river	9.5	95	1050*	1,512,000	12,535,176
14A	Derrick well	31	68	1063	1,530,720	12,743,607
14B	Molasses tank well	38	67	1063	1,530,720	12,746,161
14C	Warehouse well	74.5	66	7475	10,764,000	89,630,818
15	Mud pond overflow	--	80	50	72,000	598,402

*Pump is running approximately 20% of time.

Table 15. Average of all chemical data.

Sample	COD (mg/l)	BOD (mg/l)	Solids (mg/l)			pH
			Total	Suspended	Dissolved	
1A. Fly ash pump effluent	1,560	66	16,300	15,040	1,260	8.6
1B. Fly ash pond effluent	19	10	413	15	398	8.2
2. Excess condensate	408	220	485	58	427	8.1
3. Floor sweepings	368	-	1,428	65	1,363	--
4. Filter mud disposal (small pipe to river)	37,400	21,500	135,000	119,000	16,000	8.4
6A. East condenser water canal (cane wash)	35	15*	452	17	435	7.4
6B. West condenser water canal	144	70*	540	23	517	7.4
7. Canal wash effluent	374	285	3,560	2,370	1,190	7.8
8. Discharge to river (large pipe)	257	152	802	175	627	7.0
9A. Input water (derrick-well)	4	0	437	0	437	7.3
9B. Input water (warehouse well)	0	0	288	0	288	7.0
9C. Input water (molasses tank well)	0	0	403	0	403	7.2

*Adjusted value --Based on COD/BOD ratios.

Table 16. Characteristics of wastewater discharged from plant.

Sampling point	Flow mgd	BOD		Pop.* equiv.	COD		Total solids		Suspended solids	
		mg/l	lb/day		mg/l	lb/day	mg/l	lb/day	mg/l	lb/day
Discharge from plant to on-site sedimentation ponds and ditches										
1A. Fly ash pump effluent	0.07	66	38	224	1,560	910	16,300	9,500	15,040	8,800
1B. Fly ash pond effluent	0.01	10	1	6	19	2	413	34	15	2
2. Excess condensate	0.03	220	55	324	408	100	485	120	58	15
6B. West condenser water	3.6	70	2,100	12,400	144	4,300	540	16,200	23	690
7. Cane wash effluent	2.2	285	5,200	30,600	374	6,800	3,560	65,000	2,370	43,200
Discharge from plant to Mississippi River										
4. Filter mud disposal (small pipe to river)	0.07	21,500	12,500	73,500	37,400	21,800	135,000	78,600	119,000	69,500
8. Discharge to river (large pipe)	5.8	152	7,350	43,200	257	12,400	802	38,800	175	8,450
Discharge to river (sum of 4 and 8)	5.9	405	19,850	116,700	695	34,200	2,390	117,400	1,590	77,950

*Based on 0.17 lb of BOD per person per day.

This brings up a very important competitive point that has already been brought out by other industries. If the US continues on its present path to clean up the air and water, this is good as long as other nations do the same. If they do not, then we put ourselves in a world competitive disadvantage. The point is that the necessary steps should be taken to see that the USDA establishes the same environmental standards for sugar produced on the foreign market as the EPA is requiring in the US. Then and only then will the competitive disadvantages be equalized.

In summary, a challenge exists. It is solvable by conventional methods and procedures with equipment that can be modified by a qualified engineer to economically meet the needs of your factory. It should be accepted that solving your problems before the regulatory agencies knock on your door will be much easier than trying to solve them after the door is open.

CLEANING SUGARCANE DURING HARVEST: CLEANING ROLLS OR PNEUMATICS

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INTRODUCTION

Clean sugarcane, delivered to the mill, is the desire of both the producer and processor. Trash, in the form of tops, suckers, leaves, grass and soil, costs the sugar industry through increased handling and transportation expense as well as excessive wear on equipment. The extraneous material requires power to grind, and it also affects the crystallization process.

As sugarcane stands in the field, before burning, it may contain as much as 30% trash. In the sugarcane trash analysis, the percentages are calculated by weight and the green tops make up a large portion of the sample under normal conditions. Under adverse conditions, the weight of mud in Louisiana may exceed the weight of tops. The cane tops add a considerable amount of impurities to the juice at the factory.

The large volume of dry trash, which is presently burned off, causes difficulty with harvesting and handling equipment. In Florida, supplementary cleaning is now required for mechanically harvested cane, and, if burning is prohibited, additional cleaning will be required in Louisiana.

The effect of trash on milling and the removal of trash has been the subject of much research and concern in the industry (1). Some of the first references in sugarcane literature indicate work on trash removal. Reports to the ASSCT reveal work on cleaning in the field and mill in 1941 (6). Considerable research was done during the period when the Louisiana harvest was being mechanized. More recent research on cleaning of wholestalk and chopped sugarcane has been reported by the USDA and Louisiana State University (2, 3, 4, 5).

FIELD SAMPLING

Field samples were taken at regular intervals in Florida to determine the trash content as sugarcane matures. Samples were cut by hand at ground level and all cane, suckers and tops were recovered. This would simulate a recumbent sugarcane harvester that picks up everything on the ground. The cane was cleaned by hand using standard procedures and the green and dry trash weighed separately.

This field of plant cane contained 30.4% trash in September when it was 12 months old (Table 1). The green trash made up 26.5% of the sample, so only 4% of dry trash was on the stalks. The trash content decreased until January when the growth of suckers caused an increase (Fig. 1).

Table 1. Trash content of field of C1 41-223 sugarcane during 1971-72 season.

Sampling date	Green trash	Total trash
	%	%
9-24-71	26.5	30.4
11-11-71	18.7	24.2
12-16-71	21.0	27.9
1-27-72	13.9	23.4
2-28-72	18.8	25.0
3-24-72	11.8	19.9
4-29-72	17.4	21.1

The trash content of burned cane was 18.0, 15.5 and 12.5% for the December, February and April samples, respectively. Therefore, 8 - 10% of trash was burned off by the flame. The trash content from a harvester with 2 blowers in unburned cane was 15.2% in September and 8.6% during the period February - April.

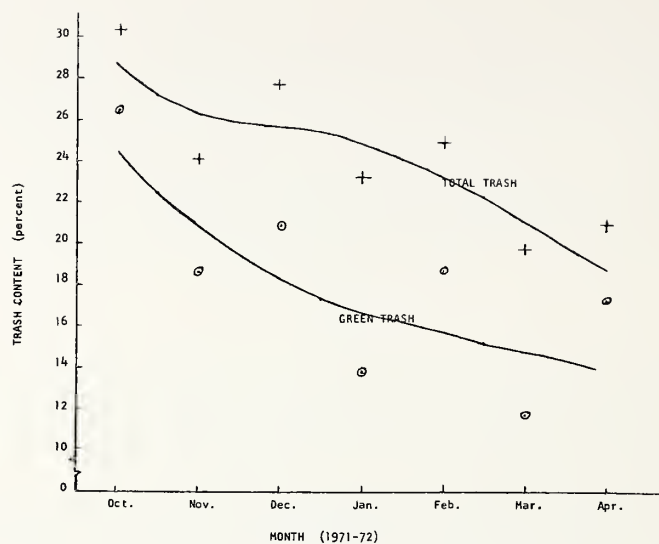


Figure 1. Trash content of unburned sugarcane as field matures.

LENGTH OF CUT--PNEUMATICS

Experiments were conducted at LSU to determine the trash removal with several lengths of cut (3). When unburned cane stalks were cut into 6-, 15- and 24-inch lengths, 78, 68 and 66% of the trash was detached from the stalks by hand cutting, respectively. With a velocity of 5050 ft per min, 98.3, 96.4 and 86.9% of the loose trash was removed by a blower for these respective lengths. The portion of the total trash removed by the blower was 77, 73 and 59%, respectively. These laboratory experiments demonstrated that a short and uniform cut was necessary for efficient cleaning.

Field experiments were made in Florida with a chopper harvester using 2 blowers and with a field cleaner using an axial extractor fan. Laboratory-type tests with the harvester resulted in 75% trash removal from 13-inch pieces of unburned cane. One air blast was directed downward at the harvester chopping knife and one at the discharge of the first conveyor. In addition to improving the trash removal, the downward air blast directed the trash to the ground under the machine.

Several experimental harvesters in Florida are using extractor fans which lift trash from the cane as it discharges from a conveyor. The trash is pulled through the axial fan and is directed into the air so that it will not fall into the cane wagon. This type of fan was developed on Australian harvesters and they are reportedly delivering cane to the mill with less than 3% trash in Australia.

An axial-flow extractor fan was mounted at the discharge of a conveyor for experimental tests in Florida. In order to determine trash removal efficiency and cane loss, unburned stalks were cut into lengths by hand and the cane and trash weighed separately. The cane pieces were marked with paint so that they could be identified after cleaning. The cane and remaining trash were separated, and the cane loss and cleaning efficiency were determined.

Cane lengths of 9 and 18 in. were used in the tests with a fan speed of 2200 rpm for the 3-blade fan. The average of 4 test with 9-inch cane lengths resulted in 52.4% of the trash being removed with 15.7% of the cane lost. A very small percentage of this loss occurred between the discharge of the conveyor and the cane wagon. With the 18-inch lengths, 59.6% of the trash was removed while 8.4% of the cane was lost (Table 2). These results are from one experimental arrangement, with a fan speed of 2200 rpm, and may not be representative of the manner in which these fans are being used in the industry.

Table 2. Trash removal and cane loss from axial suction fan using hand-chopped, unburned sugarcane.^{1/}

Sample number	9-in. lengths		18-in. lengths	
	Tops removed	Cane loss	Tops removed	Cane loss
	%	%	%	%
1	50.9	13.9	80.5	6.6
2	50.4	14.8	37.9	10.0
3	61.2	20.5	58.8	12.0
4	47.6	13.8	60.3	5.2
Average	52.4	15.7	59.6	8.4

^{1/} Experiment with 3-blade fan mounted over discharge of spike-tooth conveyor.

This severe degree of cane loss was not evident in observation of the tests although some shredded cane pieces could be recovered. An analysis by high-speed photography showed that many cane pieces were tossed near the fan by the conveyor and were lifted by the air. The entire cane piece was usually shredded and discharged with the trash. Experiments with lower velocities resulted in poor trash separation.

CLEANING ROLLS

Three-inch dia rubber husking rolls and 6-inch dia aluminum cleaning rolls have been developed in Florida. These can be used in the conveyor of a chopper harvester. The 3-inch dia rubber husking roll is the more efficient and will reduce the trash content of chopped cane from about 14% to 5% (Table 3).

Table 3. Trash content of burned, mechanically harvested cane cleaned by husking roll cleaner.

Year ^{1/}	Trash content		Cane loss
	Before cleaning	After cleaning	
	%	%	%
1968	15.0	3.2	8.0
1969	14.5	6.5	-- ^{2/}
1970	13.3	4.5	2 ^{3/}

^{1/} Average of all experiments during the year.

^{2/} Cane loss not measured.

^{3/} Estimated.

Fourteen of these 6-ft long husking rolls were mounted in a semi-circular frame with an auger for moving cane up the conveyor. Slight spirals on the rubber rolls also moved the trash up the slope as it was removed. These rolls were mounted in a conveyor at a 35° angle as they would be in the conveyor of a harvester. The cane loss was primarily at the end of the rolls and was reduced to about 2% in 1970.

Spiral rolls were also developed for cleaning chopped sugarcane. A 5/16" by 1-1/2" flat spiral was welded on pipe to make the roll. The chopped cane was dropped at the end of the roll, and the spiral thinned the cane, conveyed it to the opposite end, and removed trash by the pinching action of the spirals. The results of several experiments are given in Table 4. The average of all experiments during the development of this cleaner resulted in a trash reduction from 15.8% to 5.2% using unburned, mechanically harvested cane. Under general field conditions in Florida the unburned sugarcane could be reduced from 20% to 8% trash content and the cane loss was reduced to less than one percent in 1971. In field operation, cane was dropped from the harvester conveyor on the cleaner as a row of cane was being harvested.

Table 4. Trash content of unburned, mechanically harvested cane cleaned by spiral roll cleaner.

Year ^{1/}	Trash content		Cane loss
	Before cleaning	After cleaning	
	%	%	%
1968 ^{2/}	16.9	7.5	5.7
1969 ^{3/}	28.8	15.8	-- ^{4/}
1971 ^{3/}	28.4	5.2	0.5
1971	10.3	5.6	1.0 ^{5/}

^{1/} Average of all experiments during the year.

^{2/} Steel spiral rolls.

^{3/} Laboratory experiments, aluminum spiral rolls.

^{4/} Cane loss not measured.

^{5/} Estimated.

A cleaner made of 6" dia rolls is more durable, since larger bearings can be used. If made of aluminum, they might be light enough to incorporate in a harvester conveyor. However, they are more adaptable to a stationary field cleaner or mill cleaner.

Laboratory experiments were made at Belle Glade with spiral roll cleaners using wholestalk cane. The cleaning rolls were mounted at an angle so that the stalks of cane could flow across the 10-ft width of the cleaner. Cleaning was satisfactory if the cane was placed so that the action of the spirals stripped the leaves down the stalk. However, handling of the wholestalk material in a uniform manner was the major problem.

These rolls were later taken to Louisiana for experiments with wholestalk cane. Again, the cleaning ability of the rolls was excellent, but the stalks were turned so that they could not be conveyed uniformly.

As a result of these experiments, cooperative wholestalk cleaning tests were continued in Louisiana using the hexagonal rolls (4). The hexagonal rolls allow the stalks to remain straighter than the spiral rolls. The trash content of unburned cane has usually been reduced from 10.0% to 2.5% with this cleaner using 4 pairs of hexagonal rolls. The important factor is feeding the cane stalks over the cleaner in a thin flow. Trash removal would be improved if the stalks could be oriented parallel to the rolls. The hexagonal and spiral rolls have operated in mud with satisfactory results. The mud reduces the efficiency of the cleaner and only the loose soil is removed through the rolls.

CONCLUSIONS

The green trash content of a field in Florida varied from 26.5 - 11.8% while the total trash ranged from 30.4 - 19.9% as the cane matured. When harvested with a chopper harvester using 2 blowers, the trash content of unburned cane from this field varied from 15.2 - 8.6% during the season.

Cutting the cane stalks into short lengths detaches leaves from the stalks and makes pneumatic trash removal more efficient. Seventy-seven percent of the trash was removed by a blower from 6" cane pieces in laboratory tests in Louisiana.

Controlled field experiments with a chopper harvester in Florida resulted in 75% trash removal from 13" cane lengths by 2 blowers. An axial-flow fan removed 52.4% of the trash from 9" cane pieces while 15.7% of the cane was lost. Trash removal averaged 59.6% from 18" pieces with 8.4% of the cane lost.

Pneumatic trash separation by using blowers or suction extractors at a point where the material drops from a conveyor is the simplest method of cleaning sugarcane. These cleaners remove the lighter types of trash that have been detached from the cane.

Blowers or suction fans on a harvester generally require about 25 hp. Two, or possibly three extraction units are required on a one-row harvester in Florida. These will clean cane at the rate of 40 tons per hour.

The spiral and hexagonal rolls tumble and agitate the cane and remove the trash that is caught by the rolls. The trash content of burned cane was reduced from 14% to 5% by the rubber husking rolls with about 2% cane loss. In laboratory and field tests the spiral aluminum rolls averaged trash reduction from 15.8% to 5.2%. The cane loss was less than 1% in 1971 tests.

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A COST ANALYSIS OF TOFT MECHANICAL HARVESTING
IN ZONE 5 OF TALISMAN SUGAR CORPORATION

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ABSTRACT

Three Toft robot cane harvesters cut, cleaned, and loaded 43,901 tons of cane during the 1971-72 crop. A study of these 3 harvesters during the month of January 1972 revealed that 15,938.86 tons were harvested from 663.70 acres at a cost of \$1.28 per ton of cane. This is less than half the cost of the hand-cut method. The cost shown includes owning cost, operating labor, repair labor, labor overhead at 25%, repair materials, fuel, oil and grease. The harvesters were scheduled to operate both day and night but often one or more did not operate through no fault of the machines. There were several occasions when the harvesters were not operated in order to use the operators or equipment in the hand-cut method. Thus, the harvesters could have produced more during the period studied.

INTRODUCTION

Talisman Sugar Corp. increased mechanical harvesting of cane during the 1971-72 crop by putting into operation 3 track-mounted Toft Robot harvesters, in addition to the rubber-tired model used in the previous crop (1). A plan was made before the crop to secure detailed information of production and cost data for each of 3 harvesters to be used in zone 5 (formerly Eastern Division of Florida Sugar Corp.). A form was designed (Fig. 1) to record the data, both day and night, and 2 men were hired to do this recording.

This paper details results of the study for the month of January 1972. This period was chosen as representative of normal operations, although the results were not as good as we expect in the future. The hand-cut, continuous loader system was often favored at the expense of the harvesters in order to accelerate deliveries to the mill.

MATERIALS AND METHODS

The study covers 3 Toft robot cane harvesters, 1 that is mounted on wheels (no. 608) and 2 that are mounted on tracks (nos. 609 and 610). The harvesters cut, cleaned, and loaded cane into strings of 3 or 4 cane carts pulled either by D-4 or Dw-6 tractors. The tractors hauled the cane to a single transfer station where the cane was transloaded into trailer trucks and delivered to the Talisman mill.

Records were kept and noted on the daily report form for each of the harvesters. Each minute of the day was accounted for in 1 of 9 categories. We started with 10 categories but soon included item 2 (traveling around ends of fields) in item 5 (actual cutting and loading). Fig. 1 is a copy of the record of harvester (610 in the day shift on January 7, 1972).

A service truck crew reported fuel, oil, and grease used for each machine. These data along with repair parts and repair labor were reported to the R & M supervisor who summarized this information on a monthly basis.

RESULTS

All 3 harvesters did a good job of cutting, loading, and trash removal. Trash determinations averaged 7.7%, with a range of 2.3 - 14.1. This compares with a 5.8% average for the entire Talisman crop.

For the month, a total of 15,938.86 tons were harvested from 663.70 acres and this is shown on a summary report for the 3 machines (Fig. 2). Considerable time was lost waiting for carts. This was caused by many things such as a breakdown of the only loading station, stops at the mill which held up trucks, shortage of equipment or operators because of operating the two systems at once, etc. The item containing the most hours was "Other and Misc." This was a catch-all category and contained time when one or more of the harvesters were not operated but were mechanically able to do so.

DATE: 1/7/72 HARVESTER No.: 610 A-11-24
FIELD: A-12-24 VARIETY: 56-59

WEED CONDITION: GOOD BURN: GOOD T.C.A. Est.: 38 T.C.A. ACTUAL: 52
54

ACTIVITY No.	REMARKS: DAY	TIME START	TIME STOP	HRS.	MIN.
10		6:00	6:40		40
7	67 Gallons fuel	6:40	7:25		45
5		7:25	7:45		20
4		7:45	7:55		10
5		7:55	8:20		25
4	Waiting for carts(rampdown)	8:20	9:30	1	10
5		9:30	10:20		50
4		10:20	10:30		10
5		10:30	11:30	1	00
4		11:30	11:40		10
5		11:40	12:00		20
4		12:00	12:15		15
5		12:15	1:15	1	00
7	Blowing off	1:15	1:25		10
5		1:25	1:40		15
4		1:40	2:05		25
5		2:05	2:35		30
4		2:35	2:45		10
5		2:45	3:25		40
4		3:25	3:35		10
5		3:35	4:00		25
4		4:00	4:10		10
5		4:10	5:40	1	30
4		5:40	6:00		20

TOTALS

1. Engines started & preparations made to begin work.-----	
2. Traveling to harvest field-----	
3. Traveling within harvest field(around ends,etc)-----	3 10
4. Waiting for trucks of carts-----	
5. Actual cutting & loading-----	7 15
6. Fueling & greasing.(list gas diesel,pounds grease,etc)---	
7. Washing & other cleaning.-----	55
8. Mechanical repairs.(List parts used in repairs)-----	
9. Waiting for repair crew.-----	
10. Other (specify).-----	40

Fig. 1. Daily Toft cane harvester log.

TALISMAN SUGAR CORPORATION										SUMMARY OF DAILY LOGS - 3 TOFT HARVESTERS						JANUARY 1972			
START UP		TRAVEL		WAITING		HARVESTING		FUELING & GREASING		CLEANING HARVESTER		REPAIRS		WAITING FOR REPAIRS		OTHER		TOTAL	
#1		#2		#4		#3 & #5		#6		#7		#8		#9		#10		TONS CANE	
Hrs.	Min.	Hrs.	Min.	Hrs.	Min.	Hrs.	Min.	Hrs.	Min.	Hrs.	Min.	Hrs.	Min.	Hrs.	Min.	Hrs.	Min.		
1	1 10		20	3 50		23 30				3 35		35				39 00		430.46	
2	1 45			9 15		9 40		35		50		40				50 15		425.79	
3	1 15		4 07	16 17		18 16		1 41		2 20		5 29				23 35		469.81	
4	2 25			11 29		23 48		1 10		2 47		25 51		1 08		3 22		745.45	
5	1 10			10 57		22 15		4 20		3 39		7 26		5 45		16 28		777.38	
6	1 20			14 57		20 05		2 05		1 30		4 25				27 38		756.16	
7	1 05		25	16 45		20 05		35		2 50		4 20				25 55		705.62	
8	1 50		15	16 13		30 52		3 20		2 10		9 25				7 55		831.91	
9	3 30			6 25		25 00		20		2 30		7 25				29 30		924.95	
10				8 12		16 58		1 35		2 30		5 00				37 45		758.50	
11				6 50		12 50		55		1 25		2 35				47 25		443.86	
12			45	10 07		3 20		30		30		30		30		64 30		171.56	
13						5 47				25		6 50		40		47 26		79.29	
14	1 10		22	10 04		11 00		35		49		10				48 50		290.86	
15				7 45		13 05		45		1 25		12 00				37 00		472.02	
16				10 05		9 55		1 00		1 20		12 00				37 40		529.04	
17	3 30		1 10	6 45		11 00		1 10		45		1 40				49 00		678.27	
18	4 40			4 5		23 10		25		1 15		1 45		10		43 50		702.53	
19	1 10		20	4 58		34 32		5 25		2 15		13 15				10 05		1,237.51	
20	1 10		30	15 00		24 25		1 20		2 15		10 40				16 40		782.89	
21	1 20		1 40	2 35		28 40		2 30		2 25		6 20				26 40		841.00	
22	1 00		15	3 25		22 50		40		4 10		1 20				38 20		435.00	
23	1 15		25	4 45		18 45		1 00		45		7 15				37 50		744.00	
24																72 00		-----	
25																72 00		-----	
26	1 15		15	25		8 55				30		55				60 45		140.00	
27			20	15		5 45				30		30		1 40		63 00		256.00	
28	1 10			2 00		6 50		1 20		1 00						60 40		116.00	
29	1 10		40	2 05		19 05		20		20		4 35				44 40		149.00	
30	3 30			1 45		14 20		1 05		1 10		2 00				51 10		268.00	
31	3 35			8 50		23 10		30		1 30		05				37 20		776.00	
1. 19 25			11 49	214 54		507 53		35 06		49 45		155 01		9 53		1,228 14		15,938.86	

Fig. 2. Summary of daily logs of 3 Toft harvesters.

The total cost per ton harvested in January was calculated at \$1.28, as follows:

One wheel-mounted harvester cost	\$ 52,000.00
Two track-mounted harvesters cost	<u>136,000.00</u>
Total harvester cost for the 3	188,000.00
Annual cost with 10-year life	18,800.00
Annual interest	<u>9,400.00</u>
Total owning cost per year	\$ 28,200.00
Owning cost per crop day (110 days)	256.36

Costs For January 1972

	<u>Total</u>	<u>Per ton cane</u>
Owning cost (31 days)	\$ 7,947.16	\$.50
Operating labor	5,319.60	.33
Repair and service labor	2,277.18	.14
Labor overhead 25%	1,899.20	.12
Repair parts	1,400.20	.09
Fuel	948.24	.06
Oil and grease	<u>673.97</u>	<u>.04</u>
Total	\$20,465.55	\$ 1.28

The total tons harvested with the 3 Toft harvesters in January was 15,938.86.

DISCUSSION

In general, we can say that although a total of 43,901 tons of cane were harvested by the 3 Toft machines during the crop, much more could have been harvested by them.

The cost of \$1.28 per ton cane is less than half the cost of the hand-cutting and continuous-loader operation for the 1970-71 crop at Florida Sugar Corp.

The cost of Toft harvesters has gone up and probably will go higher in the future, but with better use of this equipment and with engineering improvements that will be made, I believe that the cost per ton will be even less than \$1.28.

Talisman Sugar Corp. expects to have a total of 24 Toft harvesters and will use them to completely mechanize the harvest of future crops.

ACKNOWLEDGEMENT

The writer wishes to thank all who assisted in the preparation of this paper and especially Neal Hart, who provided repair and service cost data, and Mr. Bobby Mills, who assisted in the cost calculations.

REFERENCE

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EXPERIMENTAL 2-MACHINE APPROACH
TO SUGARCANE HARVESTING IN FLORIDA

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ABSTRACT

During the early part of 1970, the Sugar Cane Growers Cooperative of Florida instituted a program to investigate the different problems of harvesting and planting of sugarcane in Florida. All of the mechanical harvesting systems which are used in Florida today utilize the combine harvesting approach. That is, a machine, whether single or multi-row, tops the cane, cuts the cane stalks at the ground line, chops the cane into short lengths and loads the cane into field wagons or other vehicles in one operation. The Sugar Cane Growers Cooperative of Florida used 2 machines in the harvesting operation rather than the single or combination machine approach. One machine was used to top 2 rows of cane, cut the stalks at the ground line and place this full length cane in a windrow in the middle between the 2 rows being cut, with the stalks oriented parallel to the length of the rows. A 2nd machine was then used to pick up the windrowed cane, cut it into short lengths and load the cane into infield cane wagons. During the 1971-72 harvest season, the 2-machine approach to harvesting was applied on an experimental basis and this paper deals with the results obtained with this experimental harvesting system.

INTRODUCTION

The Sugar Cane Growers Cooperative of Florida instituted a Research and Development Division during the early part of 1970 to do research work primarily in the area of sugarcane harvesting. The approach considered for harvesting cane for the 50-member cooperative was a 2-machine method rather than a single or combine machine method, which is being used at this time on an experimental basis at other sugar companies in Florida.

This 2-machine approach to harvesting consists of one machine which tops the cane and cuts the cane at the base 2 rows at a time and places this full length cane into a windrow in the middle between the 2 rows being cut, and a 2nd machine which picks up the windrowed cane, chops it into short lengths, cleans the cane, and loads the chopped cane into an infield wagon which moves along with the loading machine in the field.

During the latter part of 1970, one cutter windrower machine and one loading machine were fabricated in the Cooperative's Research and Development shop and used on a very limited experimental basis at the end of the 1970-71 harvest season.

With the knowledge gained from this short experimental period, the cutter-windrower machine was slightly revised and a completely new loading machine using the features of the 1st loading machine was constructed. These 2 machines were used on an experimental basis during the 1971-72 crop season, and this was the 1st season of experimental operation of the 2-machine method of harvesting at the Sugar Cane Growers Cooperative of Florida.

MATERIALS AND METHODS

The two row cutter-windrower machine used during the past harvest season is a track mounted, hydrostatically driven unit which windrows 2 rows of cane at a time. The tops of the cane are gathered by finger type chains and cut with circular segmented blades. Each toppler is hydraulically adjustable to cut the cane tops at varying heights throughout the field. The cut tops are directed into chutes ahead of each track, where they fall to the ground in the furrows outside the lines of cane being cut.

After topping, the cane stalks are cut at the ground line by circular segmented bottom blades which are individually height adjustable by hydraulic cylinders. Kicker rolls located immediately above the bottom blades move the full length cane stalks into the middle between the 2 rows being cut, with the stalk lengths parallel to the line of travel of the machine. A confining chute located under the machine immediately behind the bottom blades holds the cane as the machine moves down the field and insures a very even and uniform windrow.

Screw type augers or crop lifters located ahead of each track lift downed or tangled cane between the rows and separates this tangled cane. Should the cane be too tangled for separation, parting saws located at the top of each auger cuts through the tangled mat and prevents uprooting of the cane stubble

with forward movement of the machine. Gauge wheels regulate the height of the crop lifters and insure that the augers get under cane which is lying flat on the ground. These gauge wheels also prevent "digging in" when there are height irregularities or undulations in the field. This cutting machine weighs 24,500 lb and exerts a bearing load on the ground of approximately 5 psi.

The 2nd machine in this 2-machine system is a track mounted loader-cleaner unit, hydrostatically driven, which loads the windrowed cane into infield cane wagons. The windrowed cane is picked up at the ground line by a series of finger type slats and the cane is moved up and through the machine to a drum-type, triangular bladed chopper which cuts the full length cane pieces into lengths of about 8 - 14".

Gauge wheels are located at the front of the pick up apron; they insure a constant height relation between the ground line and the pick up head even though there are undulations existing in the field.

A plate-type agitating roll located about midway of the pick up system provides the initial cleaning of the cane by dropping out muck and small pieces of trash as the cane moves through the machine to the chopper. A floating hold down conveyor applies pressure to the cane and aids positive movement of the cane to the chopping mechanism.

As the chopped cane pieces fall from the chopper into the loading conveyor, an air blast provided by a centrifugal blower is applied to the cascading cane and removes some of the trash, which is directed downward and into the furrow beneath the machine.

The chopped cane pieces move up the loading conveyor and fall upon a series of agitating rolls which are located at the end of the loading conveyor. These rolls help separate the trash from the cane, and an axial suction type fan located above the rolls removes trash from the cane as the cane falls into the infield cane wagons.

This loader-cleaner machine weighs about 31,500 lb and, as the cutter machine, exerts a pressure of about 5 psi on the ground.

RESULTS AND DISCUSSION

During this past harvesting season, 11,047 tons of cane were harvested mechanically by this 2-machine harvesting method. Of this total, 10,561 tons were harvested on an experimental production basis over a period of 79 days for an average of 134 tons of cane per day. This average figure of 134 tons per day includes breakdowns, repairs, minor field changes and adjustments, experimentation, and standby time in the field. The remaining 486 tons of cane were harvested during periods which were devoted to experimentation only, with no consideration given to harvesting cane on a production basis.

Since this was strictly an experimental harvesting system, many problems, delays, and interruptions were encountered which would not be present when harvesting on a production basis.

The cane harvested during the season varied in tonnages from a low of about 25 tons per acre on the "cold land" away from Lake Okeechobee to a high of 80 tons per acre on the "warm land" around the lake, with the average for the cane harvested mechanically being in the range of 45 - 55 tons per acre.

A variety of field conditions were also encountered during the course of the season from the very soft muck of reclaimed vegetable land to the extremely hard and compact marl type soil immediately adjacent to the lake. Cane was harvested in fields of near flat culture to fields with rows of 6 - 8" in height.

These varying conditions of cane tonnages, types of soil, and cane cultivation methods provided a very representative sample of the harvesting conditions existing on the farms which are harvested by the Cooperative.

The quality of the cane harvested mechanically was approximately the same as the hand cut cane except for the amount of trash present in the cane delivered to the mill. In the trash analysis of mechanically harvested cane, the highest percentage of trash recorded was 17.72% and the lowest recorded was 5.03% with the season average being 11.76%, which compared to a season average of 6.24% for hand cut cane.

The sucrose and purity values of mechanically cut cane did not differ greatly from hand cut cane and Table 1 provides a comparison of these values for the season. Only the juice analyses of cane taken on the same days and from the same fields are used in this tabulation as a comparison of the 2 systems.

From an operational standpoint, the two row cutter-windrower machine operated very well during the entire season and provided a very uniform windrow and ground cut in all varieties of cane and ground conditions encountered. Tangled and downed cane did not give any problems in the machine's operation, and the unit provided an even windrow under these conditions.

Table 1. Quality comparison of hand cut cane and machine cut cane for 1971-72 crop season.

Date	Variety	Hand cut			Machine cut		
		Brix	Sucrose	Purity	Brix	Sucrose	Purity
12-23-71	C1 41-223	15.46	12.07	78.07	15.06	11.71	77.76
12-26-71	C1 41-223	16.19	12.61	77.89	17.45	14.61	83.72
12-27-71	C1 41-223	15.71	12.15	77.34	16.96	13.46	79.36
1-4-72	C1 41-223	16.66	13.65	81.93	16.63	13.71	82.44
1-7-72	C1 41-223	17.56	14.31	81.49	16.47	13.07	79.36
1-11-72	C1 41-223	16.78	13.43	80.04	17.04	13.83	81.16
1-12-72	C1 41-223	17.24	13.73	79.64	16.56	13.00	78.50
1-13-72	C1 41-223	17.07	13.74	80.49	16.91	13.52	79.95
1-14-72	C1 41-223	17.49	14.16	80.96	17.24	13.70	79.47
1-15-72	C1 41-223	16.86	13.65	80.96	17.26	14.12	81.81
1-27-72	C1 41-223	16.76	13.57	80.97	16.84	13.51	80.23
1-28-72	C1 41-223	16.96	13.90	81.96	17.55	14.42	82.17
1-29-72	C1 41-223	17.13	14.18	82.78	17.16	14.03	81.76
2-2-72	C1 41-223	16.27	12.70	78.06	15.40	12.32	80.00
2-13-72	CP 57-603	18.28	15.17	82.99	17.35	13.84	79.77
2-16-72	C1 41-223	18.13	14.70	81.08	16.25	12.72	78.28
2-22-72	C1 41-223	17.75	14.52	81.80	17.56	14.42	82.12
2-23-72	CP 57-603	17.08	13.49	78.98	17.19	13.34	77.60
2-24-72	CP 57-603	16.78	13.26	79.02	17.32	13.74	79.33
3-4-72	C1 41-223	19.33	15.97	82.62	18.15	14.92	82.20
3-6-72	C1 41-223	17.55	14.38	81.94	18.27	15.02	82.21
3-8-72	C1 41-223	17.44	14.07	80.68	16.80	13.10	77.98
3-11-72	C1 41-223	18.38	15.70	85.42	16.35	13.30	81.35
3-12-72	C1 41-223	18.07	15.42	85.33	17.77	15.02	84.52
3-13-72	C1 41-223	18.16	15.47	85.19	17.97	15.53	86.42
3-14-72	C1 41-223	18.14	15.23	83.96	17.69	15.09	85.30
3-15-72	C1 41-223	17.10	14.28	83.51	17.23	14.26	82.76
3-16-72	C1 41-223	17.31	14.35	82.90	16.77	13.79	82.23
3-16-72	C1 41-223	16.76	14.02	83.65	16.29	13.62	83.61
3-17-72	C1 41-223	18.04	15.07	83.54	19.60	16.78	85.61
3-18-72	C1 41-223	18.32	15.57	84.99	17.38	14.48	83.31
3-18-72	C1 41-223	18.13	15.31	84.46	19.01	16.40	86.27
3-19-72	C1 41-223	19.05	16.37	85.93	18.33	15.62	85.22
3-21-72	C1 41-223	18.42	15.56	84.47	18.46	15.62	84.62
3-22-72	CP 57-603	17.75	14.72	82.93	16.49	13.13	79.62
3-23-72	C1 41-223	17.40	14.47	83.16	17.70	14.76	83.39
3-25-72	C1 41-223	16.89	14.09	83.42	16.84	13.44	79.81

The availability of this cutter machine was very good throughout the season as little or no downtime was experienced in its operation. The only downtime experienced was caused by a malfunction in one of the hydraulic circuits and an occasional choke in the auger or croplifters and in the kicker units above the bottom blades.

The loader-cleaner machine operated sufficiently during this past harvest season considering that this was the machine's first field operation. Picking up of the windrowed cane was fairly good and the chopped cane averaged about 8 - 14" in length.

The availability of this machine was not nearly as good as the cutter machine as there were many problems involved with the machine's initial operation; most were solved during the season. About 90% of the downtime on this loading machine was due to the conveying chains being too light for the application and the shearing of bolts in the slats of the pick up and conveying systems. This problem should be solved in the future by using conveying chains of a higher working strength.

The expected capacity of this 2-machine system was not attained during the season due primarily to the breakdowns and delays involved with the loading machine and the highest daily production rate was 400 tons. With the elimination of small breakdowns and other delays, the loading machine should be capable of loading 500 tons of cane during a normal 10-hr work day.

Initially it was anticipated that 1 cutter-windrower machine would be necessary to supply cane for 1 loading machine; however, from our first season's experience, it appears that one cutter machine will provide enough cane for 2 loading machines. This will greatly reduce the number of machines and operators necessary to harvest cane by this 2-machine method.

No particular field preparations over what is in existence today in the hand cut system have to be made for this 2-machine approach since the cutter machine can open the fields at any point. The loading machine can begin at any point in the field, and this factor eliminates the setting up of special roadways or firelanes and provides for the maximum use of acreage for growing cane.

CONCLUSION

In general, the 2-machine method of harvesting cane has proved to be a very good harvesting system on an experimental basis and it is felt that this will prove to be a very sound and flexible system which will promote maximum usage of equipment, manpower, and acreage.

What effects harvesting cane by this method will have on milling and what the costs will be per ton of cane harvested are things which can only be answered by putting such a system into a production operation.

For the 1972-73 season, a system of 2-machine harvesting will be put on a production basis as a separate harvesting unit at Sugar Cane Growers Cooperative. This operating unit will consist of 1 cutter-windrower machine and 2 loader-cleaner machines with a standby unit of each type. Only after this system has been put on a production basis can the true production capabilities, costs and merits of a 2-machine system be determined. It is expected that at the end of the 1972-73 harvest season all questions relative to this type of harvesting system will be answerable.

TWO-ROW SUGAR CANE COMBINE

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and

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ABSTRACT

This paper analyzes data obtained from the use of a J&L S6, Series C, 2-row cane combine purchased in 1971 by Osceola Farms Company of Pahokee, Florida. This machine was integrated into a group with 3 existing Series B S6 combines. This new machine was basically the same as the existing ones, except that all mechanical drives were replaced by hydraulic drives in an effort to lower maintenance and repair costs. All machines worked as a group, loading cane into strings of 4 carts similar to the present continuous loader operation. In order to evaluate the performance of the new hydraulic machine, a special test was set up on March 8, 1972. For the last 16 days of the season, special records of the hours worked, tonnage per day, and average tonnage in each string were kept on the new harvester. This test showed marked improvement in these areas for the new machine over the older ones. Preliminary data show the new machine worked an average of approximately 8-hr each day for the duration of the test, which indicates that downtime due to maintenance was considerably reduced. We feel that final analysis of the tonnage figures will show that the machine averaged 450 - 500 tons per 10-hr day for the duration of the test.

INTRODUCTION

In 1971 Osceola Farms Company of Pahokee, Florida purchased a S6, Series C, 2-row cane combine from J&L Engineering Company. This machine was integrated into a group with 3 other Series B combines and started cutting in December 1971. The Series C model had been redesigned in an attempt to lower maintenance costs and to reduce downtime in the field due to breakdowns. It soon became apparent that the new machine was indeed performing considerably better than the previous models, but, because it was working in a group including 3 older machines, the extent of this improved performance was difficult to isolate. Therefore, on March 8, 1972, a special 16-day test was set up to gather data on the new machine. These data form the basis for this report.

All machines loaded into the same carts presently used with the hand cutters and continuous loaders. Four of these carts were pulled by a 4-wheel drive tractor and carried about 15 - 16 tons per trip.

APPARATUS AND METHODS

The S6 combine is a 2-row track-mounted cane harvester which is used in the Florida sugarcane producing area. Both rows of cane are topped as the cane reaches the front of the machine, and the tops are deposited to the left of the machine. The pickup head consists of a series of rotating drums which have fingers or plates attached to them. The 1st drum is placed above and to the rear of 2 circular, high-speed bottom cutting blades which are independently adjustable by the blade operator. This adjustment allows approximately 4 - 5" difference in the height of the cut between each row, thereby allowing proper stubble cuts regardless of minor variations in the row elevations. This pickup drum and blade arrangement effectively sweeps the area between 2 rows of cane and very little scrap is left in the field. Conveyors bring the cane up to the cross-flow cutter which cuts the cane into pieces with a sickle type of action. The cross-flow cutter drops the cane pieces onto a cross conveyor which elevates the cane and drops it into the wagons. As the cane leaves the conveyor, a 4-bladed suction type fan pulls some of the trash out of the cane and blows it over the wagons to the cut portion of the field.

All elements of the entire Series C combine are driven by hydraulic motors, including a variable speed hydrostatic system on the propulsion drive. The redesign mentioned above included 2 high speed motors for the bottom blades, 1 low speed motor for the pickup-holddown conveyor assembly, and 1 low speed motor for the cross-flow cutter sickle action.

During the duration of the 16-day test, data for the whole group was recorded by Osceola Farms personnel on their standard daily field report. One of these reports is included in the data for reference as Table 1. Also, data on the number of loads, tonnage, hours operating, etc. for each machine was recorded by a special man assigned to the actual fields where the machines were operating (see Table 2).

OSCEOLA FARMS COMPANY				
MECHANICAL HARVESTING				
DAILY REPORT <u>108</u>		ZONE <u>1</u>	DATE <u>3/12/72</u>	
HARVESTER NUMBER	HOURS WORKED	HOURS LOST	REMARKS	
260	7	4	Start 8:00 a.m.	
261	1½	4½	Open Field 11:30 a.m.	
			Maintenance: Blade	
262	2	6	Maintenance: Differential	
263	9	2	Open field time included.	
TOTAL	19½	16½		
FARMER	FIELD	ROWS	ACRES	TONS
N. Hope	16-W #3	28	11.2	383.25
N. Hope	16-E #3	60	14.0	623.29
	EFFECTIVE RATE - 54 Tons/Hr. Operating			
	AVERAGE LOAD - 14.60 Tons/String			
TOTAL				1006.54
/s/ J. Macia				

Fig. 1. Typical daily field report.

HARVESTER NUMBER	260	261	262	263	GROUP TOTAL
TOTAL TONS	2,940.92	1,362.98	3,394.22	5,624.59	13,322.71
TONS/DAY	184	85	212	352	835
TONS/LOAD	12.46	12.28	13.47	15.49	13.85
HOURS WORKED	82	41.5	79.5	117.0	320
HOURS STANDBY	46	70.0	51.5	29.5	197
HOURS REPAIR	70	67.5	44.0	33.5	215
TOTAL HOURS	198	179.0	175.0	180.0	732
TOTAL HOURS PER DAY	12.4	11.2	10.9	11.3	45.8
TONS/HR ACTUALLY OPERATING	35.8	32.8	42.7	48.0	42.0
TONS/HR AVERAGE*	19.4	12.5	27.5	37.4	25.0
% WORKING TIME	41.4	23.2	45.4	65.0	43.8
% STANDBY TIME	23.2	39.1	29.4	16.4	26.9
% REPAIR TIME	35.4	37.7	25.2	18.6	29.3

*Based on hours actually operating plus hours in repair.

Fig. 2. Data from a 16-day test.

RESULTS

The new machine cut and loaded 5,624.59 tons of cane during the 16-day test for a rate of 352 tons per day. During the test, it actually cut for a total of 117 hr, or 7.3 hr per day. This figure yields an hourly cutting rate of 48 tons per hr actually operating. It must be pointed out here that approximately 1-1/2 days of lost time included in the above data were due to failure of a repaired shaft which everyone knew was a calculated risk at the start of the test. If this time is deleted, the figures change to 388 tons per day and 8.1 hr per day operating. Analysis of Table 2 shows the new machine (#263) cut approximately 66% more cane than the next best machine (#262), and cut 47% more hr than this machine also. The percentage of repair time was reduced from 37.7% on #261 to 18.6% for #263, based on 11.3 hr in the field. The average load per string of 4 carts for #263 was 15.49 tons, which is 15 - 20% more than the other machines were loading, thereby reducing hauling costs. The reason for this increase was the new hydraulic drives which caused the cross-flow cutter to do a better job of chopping the cane into short pieces (approximately 20" long).

CONCLUSIONS

In conclusion, the results of the 16-day test indicate that the S6 combine, Series C, is capable of cutting rates of 400 tons per day for a sustained period of time. Based on a normal working day of 10 hr, this machine is capable of 40 tons per hour. Observations in the field indicate that, with proper maintenance and field supervision, this is a conservative figure. Using the above 40 tons per hr, harvesting costs per ton are calculated at \$1.17 (see Table 3). This figure includes generous amounts for cost of interest, insurance, taxes, depreciation, and repairs (both during the season and off-season).

Table 3. Estimated hourly owning and operating costs.

S6 Two Row Cane Combine

Price: \$80,000

Depreciation - hours: 8 years @ 9 hrs/day for 100 days = 7,200 hrs.

Hourly owning costs

	<u>Per hour</u>	<u>Per season</u>
Depreciation: \$80,000 ÷ 7,200 =	\$11.10	\$ 9,990
Int., ins., taxes: (\$.08/\$1,000) x \$80,000 list price	\$ 6.40	\$ 5,760
	<u>\$17.50</u>	<u>\$15,750</u>

Hourly operating costs

Fuel: 10 gph x \$.144/gal. or /kw hr.	\$ 1.440	\$ 1,296
Lube oil, engine: .1 gph x \$1.28/gal.	.128	115
Lube oil, trans.: .03 gph x \$1.28/gal.	.043	39
Hydraulic oil: .5 gph x \$1.28/gal.	.640	576
Grease: .2 lbs/hr x \$.24/lb	.048	43
Repairs: 200% depreciation per hour	22.100	19,890
Operators wage: Main operator	2.400	2,160
Blade operator	2.400	2,160
	<u>\$29.199</u>	<u>\$26,279</u>
Hourly owning cost	\$17.50	\$15,750
Hourly operating cost	<u>29.20</u>	<u>26,279</u>
	<u>\$46.70</u>	<u>\$42,029</u>

The above costs are not quotations for cost study only

At 40 tons/hour, cost = $\frac{46.70}{40}$ = \$1.17 per ton

It is obvious that the change to a completely hydraulic drive system lowered maintenance and downtime considerably. It is our opinion that the elimination of as many moving components as possible, by placing properly sized hydraulic motors directly at the point where they are required is an effective way to reduce downtime. Also, the stalling characteristic of these motors protects the components better than shear sprockets or other overload devices, especially when the load on various components varies widely as it does in cane combines. We did notice an increase in fuel consumption, as can be expected because of the lower overall efficiency of the hydraulic motors compared to mechanical drives.

The suction fan on the end of the loading conveyor contributed to the increased tonnage in each string. The outboard skirt on the lower part of the fan housing had the effect of concentrating the falling cane pieces in the center of the cart, and also prevented some pieces from being thrown over the far side of the cart. The actual percentage of trash extraction has not been determined; further work is needed in this area.

The cost of maintenance and repairs to the aluminum tube type of loading conveyor at the high tonnages of this machine was considerably greater than for the typical drag type conveyor. It appears that a change back to the drag type conveyor would contribute to lower maintenance costs. This change will be put in effect in new models.

Papers Presented at Meeting
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October 12, 1973

VISCOSITY

Guillermo Aleman
Clewiston, Florida

ABSTRACT

Viscosity is a problem which is frequently found in sugar houses. There are many steps down the line of the sugar-making process where viscosity can be produced. Without forgetting that viscosity can be induced by natural causes in the sugarcane fields, this paper emphasizes the particular aspect of man-made viscosity, either in the sugarcane field or in the sugar-making process. Recommendations are made on how to avoid troubles of viscosity which are so detrimental to the over-all capacity of any sugar factory as well as to the recovery of sugar from the cane.

SOME CONCEPTS OF VISCOSITY

It is not the intent of this paper to go into sophisticated and/or theoretical considerations about this subject, which aspects have been dealt with in depth in the several treatises on technology available to us and amply discussed in Sugar Technologists Associations' meetings throughout the world.

Our aim is rather to particularly point out, from a practical point of view, some concepts to those that day after day are facing the problems related to viscosity that arise in the process of sugar making.

The problem that we call viscosity, that is, whatever difficulties impair the handling of the sugar massecuites in the vacuum pans and centrifugal departments, would be of minor importance were it not because, aside from reducing capacity, it is always accompanied by losses of sugar. This is true not just at the time it originates, by destruction of sugars, but specially at the time of massecuite boiling, when viscosity impairs the recovery of sucrose. Recovery is impaired mainly by preventing the movement of the massecuite as a whole and the circulation and traveling of the sugar crystals and molasses relative to each other.

Most of the time that the boiling and/or the centrifuging of massecuites become a problem, the blame will be placed on viscosity. Then the solution to the problem is to make use of surfactants and/or to slow down the speed of boiling and centrifuging, sacrificing capacity, or lowering the brix of the massecuites, sacrificing recovery.

I recall having heard tales of the times when the surfactant used to speed up the drying of the C massecuite was just caustic soda because this was the only thing available to the poor old maestro de azucar. He might not have heard about surface tension, but he did know that adding a little caustic soda in the crystallizer or the centrifugals' mixer would ease and speed up the draining of the molasses in the centrifugals. But, in doing that, he was attacking the effects and most of the time neglecting the causes. And, believe me, most of the time we do the same thing nowadays.

With the development of several surface agents (there are many in the market, and they are a great aid in reducing viscosity), the detrimental effects of what we call viscosity have no doubt been minimized, but just in one direction--capacity; for even though they help to get more sucrose from the molasses to the sugar crystals in the massecuites, they are unable to bring back the sucrose already destroyed by the same cause that originated the viscosity.

So, the surface agents are an aid but not a substitute for a good process technique that avoids the formation of the compounds that cause viscosity.

We have been in this trade for quite a while and are in a position to state that most of the times that a sugar factory confronts viscosity, the evil is man made and not sprung from natural causes. That is, the viscosity is being produced by us outside the factory in the fields and/or within the factory, by faulty techniques somewhere down the line from the cane grinding through the crystallization process.

In the cane fields, viscosity can also be originated by nature, of course, as was the case in Louisiana during the last crop when a hurricane badly damaged the sugarcane before harvesting.

It can also happen in areas such as Louisiana and Florida after freezing temperatures and conditions that damage the sugarcane, depending on the duration and/or intensity of the freezing and the time elapsed between the freezing and grinding and climatic conditions during this period.

But viscosity is very easily produced independently of hurricanes and freezes if the cane is left over in the field or in storage areas for an extended period of time between cutting and grinding. So, before the sugarcane enters the sugar factory, viscosity may have been equally produced by nature or by man; but, since nature cannot talk our language, it will always be easier to put the blame on nature.

As to the first, the one due to nature, there is not much we can do except to speed up the harvesting and processing to diminish the time factor in the deteriorating process of the sugarcane. As to the second one, the man made viscosity, much can be done with proper control and synchronization between the harvesting and grinding operations.

We have thought it convenient to explain all the above concerning the possibility of viscosity being originated outside the sugar factory just to make it clear that we do not exclude this potential source of viscosity. But if you exclude the particular conditions of hurricanes breaking up canes, freezings killing them, or a prolonged time lag between harvesting and grinding, every time you hear about viscosity in a sugar factory search for the causes within the factory itself.

If we grind sound, freshly-cut cane, there is no reason to encounter trouble with viscosity in the sugar factory. But there are certainly many steps down the line of the process that, if neglected or not properly controlled, will originate viscosity; but usually the blame will be put on the sugarcane variety or the weather conditions under which it grew, and the cause will hardly ever be sought in the factory itself, where most of the time the evil is being originated. And it is this aspect of the matter that we would like to point out in this paper.

All that which we are going to enumerate from now on may seem childish and already evident to anyone familiar with the sugar making process, but let us consider just for a moment the times that each of us has been operating or visiting a sugar factory and has observed many of the faulty or careless practices we will talk about in the following paragraphs.

PILING UP CANE IN STORAGE DURING THE DAY FOR NIGHT GRINDING

We prefer to leave out of the picture the case of sugar factories that have to pile up sugarcane during the day for night grinding because these factories, unfortunately, have to choose to do that as a lesser evil. These are factories, for example, that have to haul cane through traffic-congested public highways where night-time cane hauling would be extremely hazardous. Even though in this case viscosity is generated, depending on time, height of the pile, weather conditions (specially temperature), etc., this is an inconvenience that the personnel operating the factory has to learn to live with, and there is not much that can be done to help but to grind at the highest rate possible during hauling time so as to minimize the amount of cane stored in the pile.

SANITATION OF THE GRINDING EQUIPMENT

Everybody knows the potential of this area for the development of bacteria that will destroy sugars while giving rise to the formation of compounds that will cause viscosity. Sanitation in this area, notwithstanding its importance, has been and is neglected in many cases. We have had available in the market, for some time lately, several bactericides to help control the bacterial development around the milling equipment. But let us understand clearly that these bactericides (mainly because of the small doses we are permitted to use by the FDA) are just an aid, but never a substitute for the proper flushing with hot water under pressure and/or steam. And let me tell you something: If I had to choose between the bactericides and the hot water, I could prefer using hot water.

CLARIFICATION

This, as is well known, is the stage in the process where all substances capable of creating viscosity are supposed to be eliminated from the juice. However, many times the elimination is not achieved to the proper degree; and in other instances, not only the elimination is not duly achieved, but viscosity-originating products are formed due to lack of control. We might bring into the picture several examples of how you can develop viscosity during the clarification process, but will limit ourselves to just the ones that in our opinion are the most important and most neglected. These are the ones concerning pH control and retention time in the clarifiers.

Just bear in mind that you have to accomplish the clarification of your juice by means of enemies of sugar, namely, lime and heat. This applies specially to the reductor sugars, the ones we, in sugar chemistry, improperly group under the common name of glucose. These sugars combine with the lime, giving rise to compounds that will not only cause viscosity at the end, but will attack sucrose, producing more reductor sugar (invert sugar) and so on, starting a chain reaction which nobody knows when and how will stop.

That is the reason for the old principle that establishes that the amount of lime used for cane juice clarification must be just that amount necessary for the neutralization of the juice acidity, and where the trouble arises in many sugar factories is in the manner of controlling the liming of the juice.

It is not enough to wait for the laboratory to run pH test of the composite sample of the juice run during the last hr, the last 2 hr, or the like. Laboratory tests are in this case just for checking, not for controlling. The only efficient control is that carried out automatically by means of electrometric equipments.

If the laboratory reports to you a pH of 7 in the juice of the last hr, it may easily be due to 30 min. of 5.5 pH and 30 min. of 8.5 pH. Then during 30 min. we were inverting sucrose, and during another 30 min. we were producing glucosates and many other compounds.

When this juice reaches the vacuum pan station in the form of syrup, we are headed for trouble, representing viscosity; but we will graciously put the blame on the gummy condition of the cane from which that juice was obtained, because by that time we will have forgotten that we did not have proper pH control at the time of liming the juice.

We may be told that all that which we are saying is well known by all those present; but tell us what proportion of sugar factories we have with electrometric control for the liming? And we do not mean sugar factories that have or do not have the equipment; we refer to those where the equipment is not only present but operated in due manner.

The other important thing is the retention time in the clarifiers. In this case, also, everybody and their aunts know very well that, while the juice is inside the clarifier at a temperature very close to the boiling point, some destruction of sugar and the creation of substances that create viscosity will occur.

But most of the time when the clarification needs to be improved, the solution is sought by increasing capacity, keeping the juice in the clarifier for a longer period of time.

We can honestly tell you, out of experience, that in most cases the improvement could have been achieved by the addition, or a better control of the addition, of some phosphoric acid and/or some polymer as flocculant incorporated in the juice. Please note that we have said addition, or better control of the addition. The phosphoric acid and the polymer flocculant have to be properly controlled and dosified; otherwise we will be wasting them. Uncontrolled addition of these substances might end up being harmful instead of beneficial.

What the ideal pH is for the clarification of the cane juice has been discussed for a long time. Well, we side with those claiming the neutral reaction, or slightly under it, in the clarified juice to be the best choice.

If we have a Ph of 6.6 in our clarifier juice, we may have some losses of sucrose out of inversion in the evaporation process, but, if we had it with 7.2 or 7.4, we would certainly have lost much more into the clarifier, and afterwards, originated by combination of sugars with the excess lime.

Bear in mind that for having pH 7 in the clarified juice leaving the clarifier, it would be necessary to have it at about pH 8 when entering the clarifier.

This is exactly the reason why we prefer to be on the light acid side (pH 6.6 - 6.8) in the clarified juice and to have the juice going through the clarifier at the highest possible speed so as not to need to lime the raw juice beyond pH 7.5 - 7.6.

And remember, always look for the improvement in clarification by bettering the conditions in which the operation is accomplished, mainly temperature, pH control, flocculant control, density of the juice (it must be as low as our evaporating capacity permits us), etc.

We must avoid trying to improve clarification through the enlarging of equipment because then we would be obtaining a clarified juice that may be physically cleaner, but not chemically cleaner, and the clarified juice in a sugar factory is not unlike the wife of Caesar, who not only had to be virtuous, but had to look virtuous.

The clarified juice not only has to look clean (physical condition), but has got to be clean in terms of sugar chemistry.

EVAPORATING PLANT

At this step of the process there is not much danger of decomposing sugars and forming compounds that produce viscosity unless the relationship between temperatures, concentration of the juice and velocity of the evaporation are out of the established standard. As the juice becomes more concentrated, the sugars dissolved in it decompose easier. This is well known, and we do not think we have to elaborate about it at this time.

VACUUM PAN STATION

It is here that we need to elaborate about the relationship between concentration, temperature, time and sugar destruction in a sugar factory and the formation of viscous compounds. If we have not been duly careful about time elapsed between cutting the cane and grinding it, sanitation conditions around the grinding equipment and efficient clarification (physically and chemically), we are surely headed for viscosity trouble in the vacuum pan department. But even with the above operations carried

out in the proper manner, we will have viscosity trouble in the vacuum pan department if any of the basic principles of sugar boiling is neglected in the operation of this department. It is very easy to create viscosity at this particular stage of the process. The causes may arise from mechanical failures in the design of the equipment, the processing techniques used and the availability of proper equipment.

Mechanical failures. The main mechanical failure in the design of a vacuum pan will be its inability to perform properly the circulation of the massecuite through the tubes of the calandria; and let us point out that we purposely say calandria and not heating element because we do not think it probable that nowadays anybody would think of boiling sugar massecuites in steam-coil-heated vacuum pans.

No matter how good the design of the vacuum pan is and no matter how high the vacuum under which it is working, we know very well that we will always have some caramelization of sugars because the portions of massecuite getting in contact or flowing near the walls of the tubes and the surface of the tube sheets will be subject to a relatively high temperature that will decompose them.

The only way to minimize this inconvenience is to make the massecuite flow as fast as possible through the tubes. As a result, we have the modern design of vacuum pans with calandria tubes of shorter length and smaller diameter and vacuum pans with forced circulation accomplished mechanically or otherwise.

Another thing to bear in mind when talking about circulation in a vacuum pan is the concentration of the massecuite while boiling. We all know that the massecuite must not be carried in the form that we call light, but it must not be carried either in such a tight condition that impairs proper circulation.

We can thus positively make the deduction that the feeding of the vacuum pans by shots is detrimental and that they must be fed in a continuous form. Today we have the means to accomplish this operation automatically, which is the only way of having the vacuum pan boiling in a steady condition of concentration. This not only benefits the circulation of the massecuite in the vacuum pan, but also eases the recovery of sucrose from the mother liquor (molasses) to the sugar crystal because of the constant and proper degree of supersaturation that is maintained.

Most of the time the forced circulation in the vacuum pan is talked about as a means of increasing capacity. However, even though this is a means of increasing the capacity of any vacuum pan, the greater benefit is the one obtained out of the sugar saved from caramelization, not only in the value of that particular sugar itself, but in preventing the formation of viscous compounds that would reduce capacity and would cause more losses of sugar farther down the line.

You might say that all these things have been known for long to the sugar technologists and do not need to be discussed or talked about any longer now. O.K., we agree with you; but, tell us, what is the proportion of vacuum pans with forced circulation and automatic feeding that you have seen working in the sugar factories that you know?

Failure in processing techniques. As to the failure in the processing techniques that can produce viscosity, they may arise from different sources. They may arise from the very moment of the graining up. If we are graining up by the old method of waiting for the grain, we have to bring the material being boiled within the vacuum pan to a high degree of concentration to reach the labile zone in the curve of supersaturation. At this high degree of concentration, the mass inside the vacuum pan moves too slowly (if it can move at all) and we are caramelizing the portion of sugars close to the heat transfer surfaces; and we will have to follow up with all the other disadvantages of this system: destroying sugars and creating viscosity.

If we grain up by the method known as shocking, the result will not be as harmful since the graining up will not be accomplished in such a high degree of concentration. The only disadvantage in this method is the lack of control in the number of crystals obtained in the nucleation.

If we wish to start up our process with a proper nucleation that down the line will spare us innumerable troubles, which would cost us sugar and create viscosity, the graining up has to be made by the method of full pan seeding. This method is the only one capable of providing us with the proper number and proper uniformity in size and shape in the nucleation that will ease the recovery of sucrose from the molasses to the sugar crystals much better than any chemical surfactant aid, even in the case of having to grind deteriorated cane.

In the full pan seeding we are not forming or originating crystals; we are just enlarging crystals that we have seeded up into the charge of the vacuum pan. From this we can see that even in the case of cane which for one reason or another has deteriorated, if we grain up by full pan seeding we will not only be spared the trouble of the needle grain, but because of the absence of conglomerates and twin grains we will not have molasses trapped between crystals, getting more viscous each time as it goes down the line of the processing.

Another matter, not less important to bear in mind if we want to avoid the creation of viscosity or to protect ourselves from it even in the case of deteriorated cane, is to take all possible advantage of desacarification by cooling instead of by heating.

Proper equipment. The previous discussion takes us to the cooling of the high grade massecuites. This operation or processing technique is so advantageous to the saving and recovery of sucrose, as well as to the economy of capacity and steam in the vacuum pan department, that we cannot but wonder why so many sugar houses do not have the available equipment to carry it out.

Just let us remember that when we are cooling off a high grade massecuite in the crystallizers before drying in the centrifugal, we are making a desacarification that would otherwise have to be made in the vacuum pans, but with a remarkable difference. In the vacuum pan it has to be accomplished adding BTU's to the sugars while in the crystallizers it is achieved by taking BTU's off the sugars, and we all know how well sugars and BTU's get along with each other.

Finally, the more you study the process of making sugar the more you realize the hazardous situation in which the sugars (sucrose, levulose, dextrose, etc.) are placed during processing.

Sometimes we have heard commentaries about the lack of progress in the sugar industry. For many people, sugar continues to be processed by old methods and with old-fashioned equipment. But this is not true. What happens is that the sugar industry progressed long ago, to such an extreme that we might say that this is the only industry that has developed its own particular technology through the years. There is no other industry that can parallel the sequence of valuable treatises in magazines, proceedings of technology meetings (like this one) that the sugar industry has enjoyed through the years. There really has been a lot of advancement in equipment and processing techniques available to us. It is up to us whether we make good use or not of the knowledge transmitted to us by Noel Deerr, Prinsen Geerligs, Spencer, Webre, Maxwell, Tromp, Honig, Gillett, Hugot, etc., just to mention a few of them.

They developed the techniques and put the tools in our hands. It is up to us to use them properly. If we do, we will surely be spared many troubles, like the one known as viscosity, within a sugar factory; as a rule it is blamed on the cane, and most of the time its origin lies in not using the proper equipment or the proper processing techniques.

SECOND REPORT ON THE EXPERIMENTAL
CUSH-CUSH SCREW PRESS OPERATION AT BRYANT SUGAR HOUSE

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ABSTRACT

This is a further evaluation of the results obtained at Bryant sugar house in the application of a French Oil Mill Machinery Co. screw press to handle cush-cush. The cush-cush screw press operated for 2205 hr out of a possible 2559 hr during the 1971-1972 crop. Most of the time lost was due to troubles unrelated to mechanical problems with the press. During the 1971-1972 crop, the work performed by the press was very similar to that done for the 1970-1971 crop. This machinery allowed us to grind approximately 50 tons per hour more when grinding high pith to fiber ratio varieties.

INTRODUCTION

We have been asked for a further evaluation of the experimental cush-cush screw press operation at Bryant sugar house.

EQUIPMENT

During the 1971-1972 crop, we kept the same 2-stage, model No. E-99, French Oil Mill Machinery Co. cush-cush screw press as for the 1970-1971 crop (Fig. 1). The installation of the D.S.M. screen, model B, 3 ft wide with 45 degree and 1.0 mm openings between the bars, proved to be the right one in our case, and we did not experience any of the problems with clarification that we had experienced before.

RESULTS

The cush-cush press worked for a total of 2205 hr out of a total of 2559 hr of operating time, and most of the time lost was due to troubles not related to mechanical problems with the press.

At the end of the crop, we experienced some difficulties with the breaker bars and excessive wear on the last stage of the press.

Due to the loss of some of the breaker bars and wear of the final stage, accompanied by an increase in the amount of trash, we had an overload on the electric motor driving the press and had to limit the amount of trash to the press in order to keep the full load on the driver.

CONCLUSION

As stated in our 1st paper, this press was not intended to improve our extraction or mill work. What we want to have from it is an increased grinding capacity when grinding certain cane varieties. In this respect, the press performed the work we were expecting, permitting us to grind approximately 50 tons per hour more when grinding high pith to fiber ratio varieties. At this time, we believe it would be of interest to point out that we ground, in 4 consecutive shifts, at an average grinding rate of more than 4000 tons per shift, or more than 12,000 tons per day. Our average grinding rate for the crop was 9931 tons per day.

As can be seen on the laboratory report on the bagasse coming out of the press, the work done by this equipment was very similar to the work performed last year (Table 1).

Table 1. Bagasse analyses averages. Bryant cush-cush screw press.

Date	Sucrose	Moisture
December 1970	5.85	63.48
January 1971	5.79	63.57
November 1971	5.82	58.63
December 1971	5.86	58.94
January 1972	5.56	58.38
February 1972	5.52	56.16

For the next crop, in order to reduce the wear on the press, which occurs mostly on the second stage, we are planning to eliminate this stage altogether. This will reduce the sucrose extraction of the press, but will have a negligible effect on the overall extraction of the tandem. It should, on the other hand, result in less downtime and substantially decrease the power consumption, as well as increase the capacity of this machine. All of this is very desirable, particularly when considering the fact that we expect a crop approximately 40% larger than the previous one.

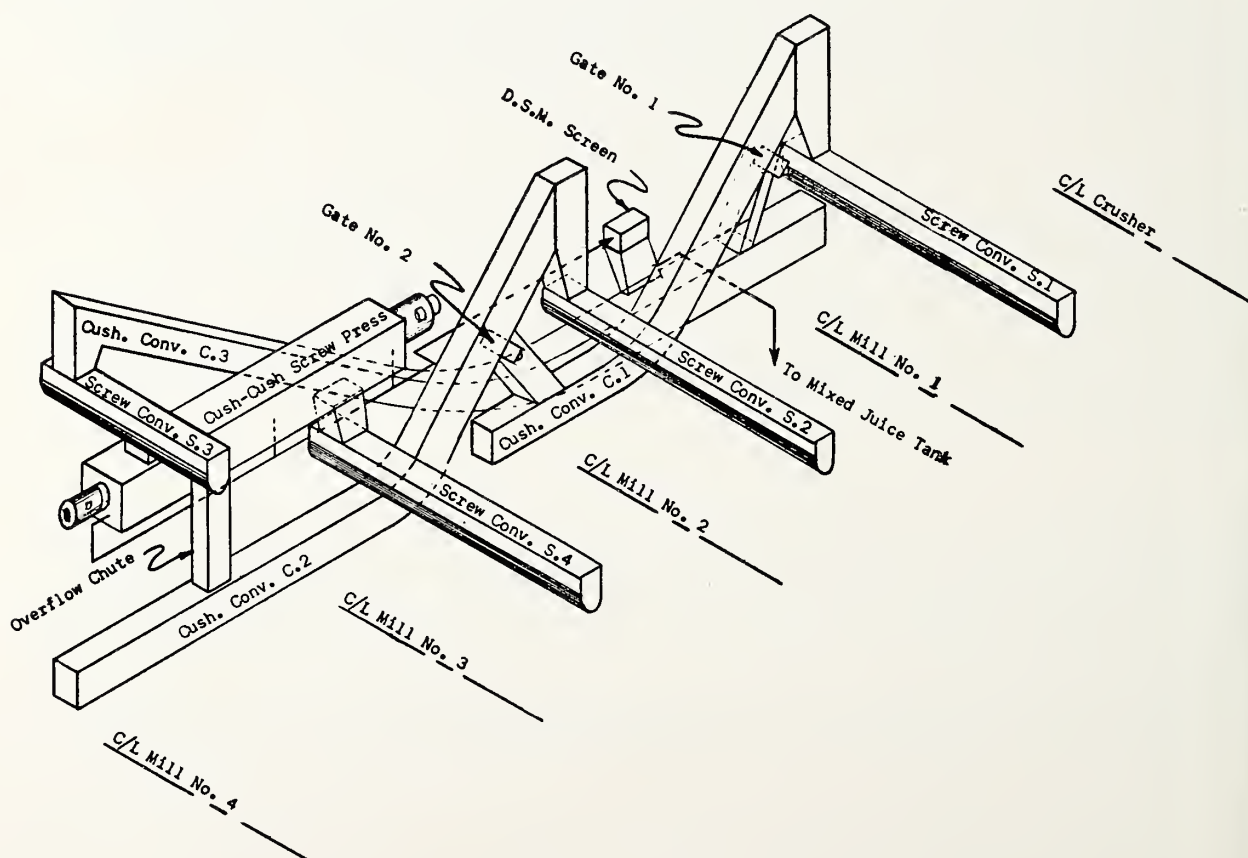


Fig. 1. Cush-cush screw press installation.

CLEANING AND MAINTENANCE OF HEATING
SURFACES IN VACUUM PANS AND EVAPORATORS

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(This paper was also presented at the joint meeting of the Florida and Louisiana Divisions of ASSCT at Pensacola in 1972 and is printed in that section of the current volume).

SUGARCANE DETERIORATION DURING STORAGE AS AFFECTED BY CHOPPING,
DELAY IN MILLING, AND BURNING^{1/}

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ABSTRACT

Raw juice pH and theoretical yield of sugar from manually chopped cane decreased significantly with storage time before milling while dextran content increased significantly. A combination of short cane pieces and long storage times resulted in rapid deterioration. Dextran content was the most sensitive measure of deterioration but was closely related to raw juice pH, which was easier to determine. Cane harvested by 3 chopper-type machines and stored in cane wagons deteriorated faster than wholestalk or conventionally harvested cane that was stored in the same manner. The calculated total sugar loss for burned cane stored for 3 days following chopper harvesting averaged 19%, while the calculated total sugar loss for conventionally harvested cane was less than 1/3 of this amount. Harvesting with 1 chopper-type machine resulted in ragged and bruised cane pieces and rapid deterioration. Burning had little effect on the deterioration rate of stored cane.

INTRODUCTION

Progress and interest in the application of chopper-type harvesters for sugarcane in Florida has increased and about 40,000 of the 252,000 total acres of cane presently grown in Florida are scheduled for harvest in this manner this year. One problem that may be encountered is post-harvest deterioration. In Australia, losses of up to 11% of sugar per unit of sugarcane and 16% of total sugar have been reported (4, 5). Losses increased with decreasing length of cut and were particularly high for cane chopped with blunt knives, where canes were split or bruised. Other changes included reductions of mill purities up to 5.8% and increases in gum content up to 4.7 mg gum/ml crusher juice. Corresponding changes for wholestalk cane were slight, indicating that storage periods apparently safe for wholestalks were unacceptable for chopped cane.

The most serious deterioration problem of chopped cane is sour storage rot caused by the bacterium Leuconostoc mesenteroides (Cienkowski) Van Tieghem (4). This microorganism has the ability to multiply rapidly and to produce dextran from sucrose. Burning has little effect on Leuconostoc sp. as it has been isolated from cane within 10 minutes after a hot burn (2). Some of the effects of dextran include an increase in the viscosity of liquids that slows mill flow, formation of undesirable needle-shaped sucrose crystals, poor clarification, and greater loss of sucrose in the final molasses (6).

Several methods of estimating deterioration have been used. The simplest of the laboratory indicators is pH of the raw juice immediately after milling. Hydrolysis of sucrose results in H-ion release and lower raw juice pH. However, Irvine (7) found it to be unreliable. Titratable acidity has been used as a quality indicator but also has not been reliable according to Irvine (7). He found that fresh cane from Louisiana sometimes had enough titratable acidity to be below industry standards. Laboratory determinations of soluble polysaccharides, particularly dextran, have proven good indicators of cane deterioration and have promise of being simple methods for classifying cane in commercial practice (9, 10, 1967b). The occurrence of dextran in chopped cane corresponded well with the 1st noticeable deleterious effects of crystal elongation during the milling process. Tilbury (13) found the haze method of dextran determination to be better than a viscosity measurement as a routine control test in the mill because it was more rapid, sensitive, and accurate.

The objectives of this study were to determine the effects of length of cut and delay in milling on deterioration of sugarcane during storage, to compare raw juice pH and dextran analyses as measures of deterioration, to compare the relative rates of deterioration in stored cane after harvest by several machines, and to compare deterioration in burned and unburned cane.

MATERIALS AND METHODS

Manually chopped cane experiment. Third ratoon sugarcane, variety C1 41-223, was burned standing and handcut the following morning. A sample of 480 stalks, each with at least 6 ft of millable cane, was randomly selected from a small area in the field. The factorialized treatments consisted of

^{1/}Florida Agricultural Experiment Station Journal Series No. 4757.

9", 18", and 36" lengths of stalk milled after 0-, 24-, 48- and 72-hr storage at 75 F in polyethylene bags to control humidity. Each treatment was replicated 4 times with 10 stalks of cane per observation. The treatments were completely randomized in storage. All cuts were made with a manually operated 1/4" blade, with 24° bevel pivoted between two 1/2" stationary shear plates. The base of each was cut approximately 3" above the original machete cut, and then each stalk was cut into two 36" pieces. The pieces were randomly placed into treatments, and those treatments requiring shorter lengths were recut.

Samples were milled in a 3-roller sample mill, and the juice was analyzed immediately for brix, pol, pH and dextran.

Dextran was determined by the haze technique (12, 9) and is defined here as the material precipitated from a starch-free, protein-free solution by 50% ethanol. Dextran levels were standardized against dextran, m.w. 100,000 - 200,000 (J. T. Baker medium fraction). Barium chloride was added to reduce sulfate interference (11). Optical densities were determined in a spectrophotometer at 720 mu. Dextran contents were expressed as % of brix (hydrometer).

Pol readings were made on leaded juice with a polarimeter, and pH was determined in raw juice with a pH meter using a glass electrode. Theoretical yield of sugar per unit cane was calculated according to the Winter - Carp - Geerligs formula (1).

Data were analyzed by 2 factor analysis of variance and linear regression.

Mechanical harvester experiment. Variety Cl 41-223 plant cane was harvested either by hand cutting or by 1 of 3 mechanical harvesters. A description of the sample source is given in Table 1. Samples from the continuous loader and the Cary and the J & L harvesters were cut and loaded the day following burning. Samples were cut by the Toft harvester the 2nd day after burning. Unburned samples from the same field were cut immediately after the corresponding burned sample. A sample of cane from each method of harvest was conveyed through an auxiliary chopping mechanism to further reduce the length of cane pieces.

Table 1. Types of samples, length and density of cane in storage study.

Sample Description	Mean lengths	Density
	(in.)	#/ft ³
Toft harvester	12.1	29.4
Toft, chopped*	8.7	29.0
Cary harvester	14.3	--
Cary, chopped *	12.3	20.9
J & L harvester	16.7	15.3
J & L, chopped*	13.9	13.9
Continuous loader	19.8	--
Continuous loader, chopped*	14.8	21.2
Continuous loader, unburned	23.5	10.9
Continuous loader, unburned, chopped*	18.8	11.0
Wholestalk	84	--
Wholestalk, unburned	84	--
Toft, unburned	12.3	20.3
Cary, unburned	14.0	21.7
J & L, unburned	15.1	14.0

* Cane was passed through an auxiliary chopper as it was being loaded.

Cane wagons were divided into sections of about 6 x 7 x 5 ft., with 2 or 3 sections in each wagon. Individual and unreplicated samples were stored in these sections for a period of 3 days (Toft samples stored only 2 days).

Density of the various samples (see Table 1) was obtained by weighing the wagons in the field using portable load cells both before and after loading a sample. A subsample was taken from the conveyors of the various machines for the 0-storage time data. Subsequent subsamples were obtained by hoisting buried cargo nets of cane from the individual sections of each wagon after 20, 32, 44 and 68 hr.

Length of cut was determined by measuring 20 pieces of cane from the 1st set of subsamples. Brix, pol and pH were determined and sugar per ton cane was calculated as in the previous experiment. Linear regression analysis was employed.

RESULTS

Manual chopping experiment. No statistically significant differences were found in the raw juice pH, theoretical yield, or quantity of dextran due to length of cut when storage time was disregarded (Table 2).

Table 2. Effect of length of cut on juice pH, theoretical yield and dextran when time of storage was not considered in manual chopping experiment.

Length of cut (in.)	Raw juice pH	lb 96° sugar/ton cane	Dextran (% brix)
9	5.39	251	0.19
18	5.40	248	0.18
36	5.41	251	0.15
	N.S. ^{1/}	N.S.	N.S.

^{1/} No significant differences at the 5% level.

Statistically significant differences were noted among storage times for all 3 dependent variables (Table 3). Theoretical yield of 96° sugar per ton of cane was significantly lower when storage was 72 hr in comparison to shorter periods. Raw juice pH decreased significantly with storage times greater than 24 hr. Dextran production increased significantly for each of the 3 storage periods.

Table 3. Effect of storage time on juice pH, theoretical yield and dextran when length of cut was not considered in manual chopping experiment.

Storage time (hr)	Raw juice pH	lb 96° sugar/ton cane	Dextran (% brix)
0	5.52 ^{a1/}	254 ^a	0.00 ^d
24	5.55 ^a	255 ^a	0.09 ^c
48	5.37 ^b	250 ^a	0.21 ^b
72	5.15 ^c	241 ^b	0.39 ^a
	** ^{2/}	**	**

^{1/} Values within a column followed by the same letter are not significantly different at the 5% level.

^{2/} Significant differences occur in a column at 1% level.

Statistically significant interactions were found between lengths of cut and storage times for the variables dextran and raw juice pH. For a 72-hr storage time, raw juice pH was significantly lower when the cane was cut either 9" or 18" than when cut 36" (Table 4). Conversely, dextran was higher for the 9" and 18" lengths than for the 36" length for the longest storage period of 72 hr (Table 5).

Table 4. Interaction between length of cut and storage time for effect on raw juice pH in manual chopping experiment.

Storage time (hr)	Length of cut (in.)		
	9	18	36
0	5.55 ^{ab1/}	5.53 ^{ab}	5.50 ^{bc}
24	5.62 ^a	5.54 ^{ab}	5.50 ^{bc}
48	5.34 ^{de}	5.42 ^{cd}	5.35 ^{de}
72	5.06 ^f	5.11 ^f	5.27 ^e

^{1/} Values in table followed by same letter are not significantly different at the 5% level.

Table 5. Interaction between length of cut and storage time for effect on dextran in manual chopping experiment.

Storage time (hrs)	Length of cut (in.)		
	9	18	36
0	0.00 ^{e1/}	0.00 ^e	0.00 ^e
24	0.11 ^{cde}	0.08 ^{de}	0.08 ^{de}
48	0.22 ^{bcd}	0.17 ^{bcd}	0.28 ^b
72	0.43 ^a	0.49 ^a	0.25 ^{bc}

1/ Values in table followed by same letter are not significantly different at the 5% level.

Both raw juice pH and dextran production were significantly correlated with theoretical yield:

1. Lb sugar/ton cane = $35.5 \text{ pH} + 58.11$; $r = 0.69^{**}$
2. Lb sugar/ton cane = $-38.06 \text{ dextran} + 256.42$; $r = -0.69^{**}$
3. $\text{pH} = -0.96 \text{ dextran} + 5.57$, $r = -0.90^{**}$

Mechanical harvester experiment. The mean lengths of cane pieces were 12.1" and 23.5" for the Toft harvester and the continuous loader, respectively (Table 1). Wholestalks averaged 84". Density in the wagons generally increased with decreasing lengths. Cane that was passed through the auxiliary chopper was reduced in length, but the density was not increased.

Raw juice pH of all samples, except for the wholestalk unburned sample, decreased with time in storage (Fig. 1) and was more evident in short-chopped cane, averaging about 0.25 units during the 3-day period. Juice pH decreased the most rapidly from samples harvested by the Cary harvester.

Data for brix and pol are not presented but decreased with increasing time of storage for short-chopped cane. Wholestalk and unburned cane samples decreased at a slower rate for these variables.

The theoretical yield of sugar in lb per ton is shown in Fig. 2. Trends in the data were similar to those for pH. Short-chopped cane in general decreased in theoretical yield at a faster rate than longer cane pieces or wholestalks. The reduction in sugar per ton of cane averaged about 10 lb per day for short-chopped burned samples.

DISCUSSION

The high correlation between raw juice pH and dextran, $r = -0.90$, for the manual chopping experiment indicated that the relatively simple determination of pH may be nearly as good as the more complicated procedure of measuring dextran. The close relationship of these 2 variables in the manual chopping experiment was the basis for measuring pH only in the mechanical harvester experiment. However, dextran measurements appear slightly more sensitive to apparent deterioration during storage, as shown in Table 3. Significantly different levels of dextran, but not pH, were recorded for the 0-vs 24-hr storage times.

Calculation of theoretical yield is probably a poorer measure of deterioration than either raw juice pH or dextran. During storage and deterioration, optically active substances other than sucrose, dextrose (D) or levulose (L) could be produced or degraded, thus altering the D/L ratio (3, 8). Even though there are serious disadvantages to using a theoretical yield calculation as a measure of deterioration, it presently offers the best means of arriving at practical figures for assessing losses due to deterioration of stored cane.

The logistics of the mechanical harvester experiment did not permit harvest of all samples simultaneously. Therefore, considerably more attention is given to the relative slopes, rate of apparent deterioration, than to the starting points of the regression lines in Fig. 1 and 2. The average loss of sugar per ton of cane was about 30 lb in the 3-day period for burned cane harvested with a mechanical harvester (Fig. 2). This is an apparent loss of about 15% of the sugar in 3 days. To arrive at real loss figures, the weight loss due to dehydration must be considered. Vallance and Young (14) found the average loss of weight for chopped cane was 1.5% per day. Using this figure, the real loss in total sugar would be 19% in the 3-day period. These calculations agree well with Australian data, which indicated 12 - 16% losses of total sugar for chopped cane stored over the weekend (4).

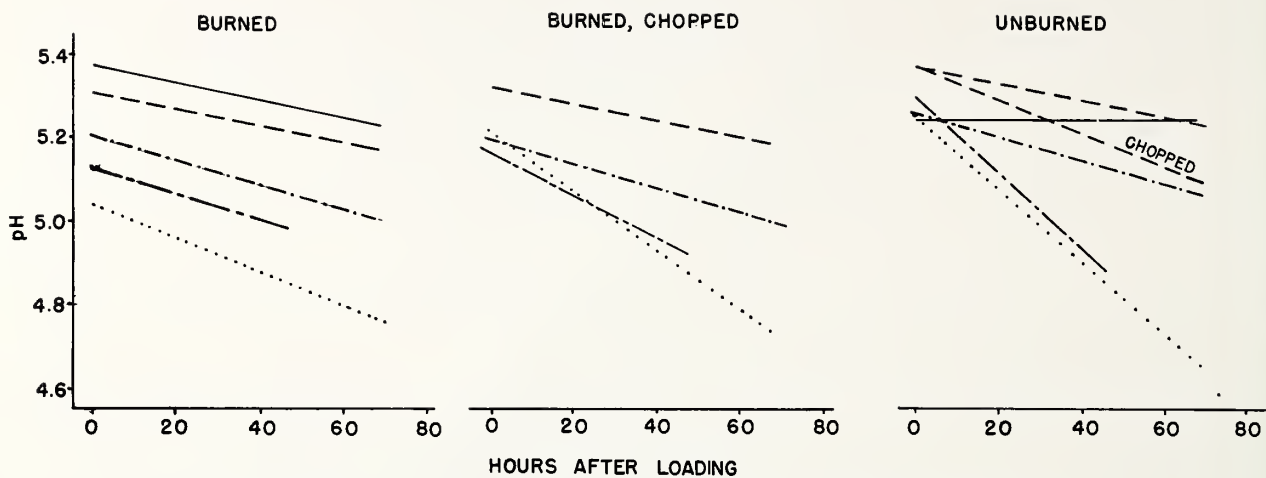


Figure 1. Raw juice pH of sugarcane harvested by several methods as affected by storage time, burning, and auxiliary chopping. — wholestalk, — continuous loader, — J & L, — Taft, ··· Cary.

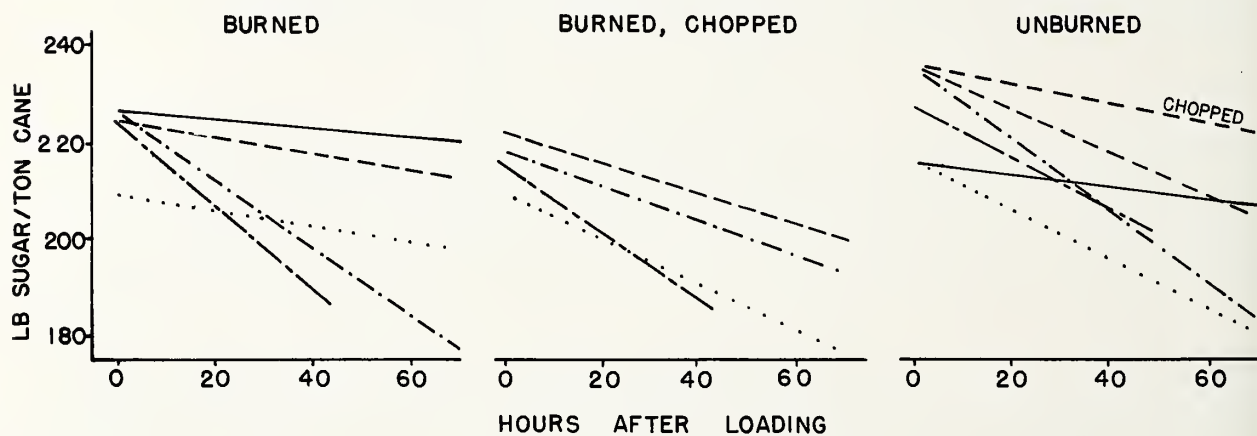


Figure 2. Theoretical yield of sugar per ton sugarcane for several harvesting methods as affected by storage time, burning, and auxiliary chopping. — wholestalk, — continuous loader, — J & L, — Taft, ··· Cary.

A calculation based on Fig. 2 indicated that the apparent sugar loss for burned, manually-cut cane that was loaded by a continuous loader was less than 5%, or about 1/3 of the loss for chopped cane in the 3-day period. The real loss for burned, manually-cut cane loaded by continuous loader would be expected to be less than 1/3 of the real loss for chopped cane because longer pieces of cane do not lose weight as rapidly as short-chopped pieces.

Deterioration as measured by pH drop was rapid for cane chopped with 1 machine. An examination of the sample chopped with this machine revealed considerable shredding, bruising and breakage of cane pieces, thus allowing for more surface area and easier entrance for Leuconostoc sp. Proper adjustment and sharp blades which make uniform clean cuts are a necessity for minimizing deterioration (4).

In addition, wagons used for storage of chopped cane and the dumping pit at the sugar house should be thoroughly cleaned regularly in order to control residual colonies of Leuconostoc sp. and prevent sour storage rot from proceeding at a rate even higher than noted in this experiment.

In Florida, both field and mill operations have in general been on a 7-day week basis. Storage periods of much longer than 24 hr should only occasionally be required. These data indicate that storage time should be as minimal as practical for short-chopped cane.

Cane used in this study was fairly mature by Florida standards as it was harvested in February and March for the 2 experiments. Results from immature cane harvested early in the season may be different. There may be varietal differences as have been noted in Louisiana (8). Results from sugarcane which had previously been badly frozen also could be different from the results obtained here.

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A PRELIMINARY ROW-SPACING EXPERIMENT WITH
SUGARCANE IN FLORIDA

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(This paper was withdrawn by the author).

THE SUGARCANE VARIETY DEVELOPMENT PROGRAM AT THE AGRICULTURAL RESEARCH
AND EDUCATION CENTER, BELLE GLADE

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ABSTRACT

The development of a new commercial sugarcane variety for Florida farmers is an 8 - 10 year program. The breeding and planting of the true seed are done at the USDA Sugarcane Field Station at Canal Point, Florida, and the seedlings are tested by the USDA and by the University of Florida's Agricultural Research and Education Center at Belle Glade. Land, labor, equipment and some financial support are provided by the Florida sugar industry and the Florida Sugar Cane League, Inc. The testing of sugarcane seedlings is a progressive step promotion system, with only the superior selections being advanced each year. Presently there are 25,000 clones in the initial phase: 1800 in stage I, 75 in stage II, 20 in stage III, and 10 plus 2 checks were advanced to outfield replicated tests last year (stage IV). Varieties in stage IV are maintained for a plant and 2 stubble crops, and the outstanding varieties are considered for release to the growers. Three varieties presently in stage IV show promise for either release as commercial varieties or for inclusion into the breeding program in hopes of raising either the tonnage or sugar content of future progenies.

INTRODUCTION

The development of new sugarcane varieties for Florida growers has been a joint effort between the University of Florida's Agricultural Research and Education Center at Belle Glade (AREC), the US Sugarcane Field Station located at Canal Point, Florida and the Florida Sugar Cane League, Inc., which represents the entire sugarcane industry. The selection process for a new variety is an 8 - 10 year program which can be divided into several phases.

EXPERIMENTAL PROCEDURES AND RESULTS

Seedlings. The breeding work for this project was conducted by the USDA at Canal Point. After studying the characteristics of potential parents, AREC and USDA personnel decided which crosses should be attempted in order to incorporate the desirable characteristics. The personnel from both stations decided on the number of seed to be planted from each available cross, after the crosses had been made, the seed harvested, weighed, and a germination test has been completed. The fuzz (true seed) was then planted in flats of sterilized soil and grown at Canal Point until the seedlings were ready for transplanting to the field. Twenty two thousand seedlings from different crosses were transplanted into the field in 1972, of which 3,306 were for selection of cold tolerant parents for the breeding program. Each November, plants are evaluated for agronomic type and approximately 10-20% are advanced to the next phase (stage I).

Stage I. From the 16,721 seedlings planted in April of 1971, 1,803 selections were advanced into stage I in November of 1971. These selections represent 38 different crosses which have many different characteristics. The 1,803 selections compare with 450 selections made in November of 1970. Plots for stage I were 1 row 10 ft long, with every 11th row planted to CP 63-588 as a check. All selections were checked against CP 63-588 for brix, vigor, flowering and other characteristics. Only about 10% were good enough for advancement into stage II.

Stage II. A total of 75 experimental varieties were selected for stage II plots, which consist of 2 rows 15 ft long. Selections received permanent numbers. Those made by AREC were designated by year and beginning with the number 2,000 (example CP 71-2001). Agronomic characteristics and juice quality were used to select the superior varieties.

Stage III. Superior stage II clones from AREC and Canal Point were considered for advancement into stage III by a variety committee made up of representatives from the AREC, the USDA and the Florida Sugar Cane League, Inc. The most promising candidates from AREC and USDA were exchanged and planted in plots 2 rows wide and 30 ft long, replicated 2 times. There were 15 USDA and 5 AREC selections advanced to stage III. All clones in this stage must be checked for juice quality, estimated yield, stalk diameter, flowering and other agronomic characteristics.

Stage IV. In this final testing stage, outstanding stage III selections must be selected by the above committee to reach this plateau. Experimental varieties selected by the committee were planted at 2 AREC and 7 USDA locations in 1/50 acre plots replicated 4 times. Ten new clones and 2 check

varieties were planted in the fall of 1971. Since replicated tests are normally located in or near a commercial field, all cultivating, insect and rodent control, burning and loading are performed as commercial practices by the grower.

Ten-stalk samples were taken at random from each plot in all replicated tests and run through a 3-roller sample mill and the juice used for determination of brix and % sucrose. Values for sugar per ton of cane and sugar per acre were theoretical yields calculated according to the Winter-Carp formula as simplified by Arceneaux (1) and reported by Rice and Hebert (2). Varieties correction factors (VCF) were applied to all varieties for which values were available. Varieties which did not have VCF's were assumed to have a VCF equal to Cl 41-223. Only data for the 1971-72 harvest season will be discussed in this report.

CP 63-485 and CP 65-357 together with the following CP 68 series -- 1020, 1022, 1026, 1031, 1067, 1115, 1145, 1154 -- were planted with 2 check varieties at Florida Sugar Corporation and at Talisman Sugar Corporation in November 1971.

Age, date of harvest, tons of cane per acre, sugar per ton of cane and sugar per acre for plant cane tests are shown in Table 1. Test no. 76 is located in section 36, which is 3 miles south of South Bay and near the Bolles Canal. In this experiment CP 66-1079 was equal to CP 63-588 in tons of cane per acre and yield of sugar per acre, but statistically lower in sugar per ton of cane. The other varieties were statistically below these 2 in tons of cane per acre. Test no. 78 is located 3 miles north of the old Florida Sugar Corp. mill and contains all varieties selected by the variety committee for planting in replicated tests in the fall of 1970. In this experiment CP 62-374 produced more tons of cane per acre and more sugar per ton of cane than any other variety and was statistically better than any other variety in yield of sugar per acre. These tests should be harvested 2 more years.

Table 1. Age, date of harvest, tons of cane per acre, sugar per ton of cane and sugar per acre for various varieties planted in the fall of 1970.

Variety	Cane per acre plant tons	Yield of 96° sugar	
		per ton of cane plant pounds	per acre plant pounds
Test FSC F-29-26 #76 harvested 12/15/71			
CP 63-485	49.64 ^{b1/}	222.4 ^b	11,052 ^b
CP 63-588	62.94 ^a	250.3 ^a	15,751 ^a
CP 66-1079	65.79 ^a	225.3 ^b	14,826 ^a
CP 67-2001	38.35 ^c	156.1 ^c	5,988 ^c
CP 67-2006	47.92 ^b	240.8 ^a	11,540 ^b
Test FSC A-3-24 #78 harvested 1/17/72			
Cl 41-223	51.73 ^b	221.5 ^{cd}	11,451 ^d
CP 56-59	64.02 ^a	230.0 ^{bc}	14,714 ^b
CP 57-603	68.06 ^a	210.8 ^d	14,360 ^b
CP 62-374	71.80 ^a	250.0 ^a	17,930 ^a
CP 63-306	50.71 ^b	242.1 ^{ab}	12,249 ^{cd}
CP 63-588	63.16 ^a	236.0 ^{abc}	14,878 ^b
CP 66-1079	65.46 ^a	205.9 ^d	13,469 ^{bc}

^{1/} Comparable means with a harvest date followed by the same letter do not differ significantly at the 5% level by Duncan's Multiple Range Test.

Table 2 gives the varieties which were harvested as 1st stubble in the fall of 1971. All 1st stubble tests were 5 x 5 latin squares and located approximately 2 miles north of the Florida Sugar Corp. mill. In test no. 66, CP 56-59 and CP 59-73 appeared to be equal to CP 50-28 in sugar per acre as 1st stubble. Some rat damage was observed in one plot of CP 56-59, but severe rat damage occurred in all plots of CP 56-63. In test no. 67, CP 66-1079 and CP 50-28 gave more tons of cane per acre and more sugar per acre than any of the other varieties as 1st stubble. CP 66-1043 was significantly better in sugar per ton of cane but had extensive rat damage, thereby reducing the tons of cane per acre. This variety will be introduced into the breeding program because of the high sugar per ton of cane. In test no. 68, CP 62-374 and CP 66-2197 gave the highest tonnage and sugar per acre as 1st stubble. CP 66-2197 will be watched closely in 2nd stubble since the variety grew upright and was self strip-ping. In test no. 73, CP 66-2197 and CP 63-485 were statistically equal to CP 63-588 in sugar per acre, but the evaluation of these 3 varieties was complicated by the rat damage on CP 63-485 and CP 63-588.

Table 2. Age, date of harvest, tons of cane per acre, sugar per ton of cane and sugar per acre for various varieties planted in the fall of 1969.

Variety	Cane per acre		Yield of 96° sugar			
	plant	1st stubble	per ton of cane		per acre	
			plant	1st stubble	plant	1st stubble
	tons		pounds		pounds	
Test FSC A-9-25 #66						
	12/16/70 ^{1/}	1/19/72	12/16/70	12/19/72	12/16/70	12/19/72
CP 50-28	33.00 ^{c2/}	46.14 ^a	208.8 ^{cd}	221.9 ^c	6,891 ^b	10,221 ^{ab}
CP 56-59*	45.45 ^a	48.77 ^a	217.7 ^d	231.5 ^c	9,897 ^a	11,291 ^a
CP 56-63**	35.70 ^{bc}	36.38 ^b	236.6 ^b	246.6 ^b	8,447 ^{ab}	8,963 ^b
CP 59-73	43.18 ^{ab}	44.39 ^a	225.2 ^{bc}	231.9 ^c	9,724 ^a	10,268 ^{ab}
CP 63-306	29.50 ^c	23.23 ^c	261.9 ^a	259.9 ^a	7,725 ^b	6,001 ^c
Test FSC A-9-25 #67						
	12/16/70	1/20/72	12/16/70	1/20/72	12/16/70	1/20/72
CP 50-28	36.55 ^c	47.49 ^a	207.7 ^{bc}	213.5 ^c	7,589 ^c	10,153 ^a
CP 66-1043**	40.10 ^b	26.06 ^b	269.8 ^a	288.2 ^a	10,819 ^a	7,491 ^b
CP 66-1078	37.48 ^{bc}	33.55 ^b	206.6 ^{bc}	238.6 ^b	7,745 ^c	8,008 ^b
CP 66-1079	48.38 ^a	47.94 ^a	204.5 ^c	223.0 ^{bc}	9,891 ^b	10,704 ^a
CP 66-1090	37.15 ^{bc}	29.94 ^b	216.1 ^b	237.5 ^b	8,029 ^c	7,108 ^b
Test FSC A-9-25 #68						
	1/6/71	1/20/72	1/6/71	1/20/72	1/6/71	1/20/72
CP 62-374	54.00 ^a	48.47 ^a	216.5 ^b	241.9 ^a	11,691 ^a	11,740 ^a
CP 65-1002	29.15 ^d	20.35 ^c	201.4 ^c	209.7 ^b	5,872 ^d	4,311 ^d
CP 66-1086**	34.50 ^c	34.08 ^c	231.0 ^a	236.5 ^a	7,968 ^c	8,071 ^c
CP 66-2197	53.13 ^a	48.69 ^a	234.9 ^a	247.0 ^a	12,482 ^a	12,014 ^a
CP 66-2207*	46.85 ^b	44.51 ^b	211.0 ^{bc}	213.0 ^b	9,855 ^b	9,479 ^b
Test FSC A-9-25 #73						
	1/7/71	1/20/72	1/7/71	1/20/72	1/7/71	1/20/72
CP 63-485*	43.50 ^b	41.24 ^b	251.0 ^a	248.7 ^{ab}	10,918 ^b	10,247 ^{ab}
CP 63-588*	51.00 ^a	43.56 ^{ab}	244.3 ^{ab}	256.7 ^a	12,457 ^a	11,152 ^a
CP 65-1063	43.50 ^b	38.43 ^b	223.6 ^c	229.5 ^c	9,727 ^c	8,830 ^b
CP 66-1056**	40.18 ^c	24.71 ^c	236.4 ^{abc}	249.1 ^{ab}	9,499 ^c	6,138 ^c
CP 66-2197	53.20 ^a	48.77 ^a	230.4 ^{bc}	237.9 ^{bc}	12,260 ^a	11,618 ^a

^{1/} Indicates date of harvest

^{2/} Comparable means within a harvest date followed by the same letter do not differ significantly at the 5% level by Duncan's Multiple Range Test.

* Some rat damage at time of harvest in 1972.

** Severe rat damage at time of harvest in 1972.

Only 1 2nd stubble test was harvested last year and the results are reported in Table 3. This experiment was located in the same field as all first stubble tests but was a 6 x 6 latin square design. CI 41-223 and CP 65-1071 were superior in pounds of sugar per ton of cane, but other varieties were superior to these in tons of cane per acre.

Table 3. Age, date of harvest, tons of cane per acre, sugar per ton of cane and sugar per acre for six varieties planted in the fall of 1968 (Test FSC A-9-25 #60).

Variety	Plant 12/29/69 ^{1/}	1st stubble 1/9/71	2nd stubble 1/19/72
Yield of cane per acre (tons)			
C1 41-223	42.71 ^{b2/}	39.77 ^b	24.10 ^c
CP 65-1018	48.69 ^a	40.17 ^b	32.17 ^{ab}
CP 65-1059	49.92 ^a	34.50 ^c	35.28 ^a
CP 65-1068	47.94 ^a	44.69 ^a	34.38 ^a
CP 65-1071	43.38 ^b	34.48 ^c	27.33 ^{bc}
CP 65-1074	38.80 ^c	30.04 ^d	34.28 ^a
Yield of 96° sugar per ton of cane (pounds)			
C1 41-223	237.0 ^a	258.2 ^a	242.8 ^a
CP 65-1018	232.5 ^{ab}	229.8 ^b	224.3 ^{bc}
CP 65-1059	223.3 ^b	207.7 ^c	201.2 ^d
CP 65-1068	208.9 ^c	231.6 ^b	225.9 ^b
CP 65-1071	224.5 ^b	248.3 ^a	239.9 ^a
CP 65-1074	203.2 ^c	231.4 ^b	212.2 ^{cd}
Yield of 96° sugar per acre (pounds)			
C1 41-223	10,120 ^b	10,267 ^a	5,877 ^b
CP 65-1018	11,322 ^a	9,230 ^b	7,222 ^{ab}
CP 65-1059	11,147 ^a	7,165 ^c	7,141 ^{ab}
CP 65-1068	10,017 ^b	10,351 ^a	7,749 ^a
CP 65-1071	9,738 ^b	8,562 ^b	6,609 ^{ab}
CP 65-1074	7,883 ^c	6,952 ^c	7,292 ^{ab}

^{1/} Indicates date of harvest.

^{2/} Comparable means with a harvest date followed by the same letter do not differ significantly at the 5% level by Duncan's Multiple Range Test.

VARIETY RELEASE

All varieties which have been through 2nd stubble tests were eligible for release, but none of the varieties harvested as 2nd stubble this year could be recommended for release from this data. Should a variety have appeared favorable, the variety committee would have recommended to the cooperating agencies that the variety be released. The Florida Sugar Cane League, Inc. would have been responsible for an equitable distribution of seedcane of any new variety. Ten varieties have been released in this manner since 1966 through the cooperative agreement of the three agencies.

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Florida Sugar Corp., which was later purchased and absorbed into Talisman Sugar Corp., provided supervision, land, and labor for all 4 stages of the AREC variety research program.

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Mr. F. leGrand, Assistant Agronomist, University of Florida, Gainesville, previously Assistant Agronomist, AREC, initiated tests 60, 66, 67, 68, 73, 76 and 78.

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DEVELOPMENTS IN SUGARCANE PLANTING AT
SUGAR CANE GROWERS COOPERATIVE OF FLORIDA

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ABSTRACT

Due to the problems in obtaining hand labor and the rising costs for planting cane during recent years, it has become imperative for Florida cane growers to make advances in this phase of sugarcane farming. The Sugar Cane Growers Coop. designed and developed planting wagons of which 32 were used during the 1971 planting season. Though not completely automatic, the use of these planting wagon units eliminated some hand labor from each planting crew and provided a substantial labor savings over the systems employed in the past. During the 1971 planting season, these new planting wagons were exclusively used and a total of 5,100 acres of sugarcane were planted with these units.

INTRODUCTION

Prior to the 1970 planting season, the Sugar Cane Growers Coop. designed and developed a sugarcane planting aid wagon which was used on an experimental basis during the 1970 planting season. The chief reasons for designing this planting aid were the increasing difficulties in recruiting hand labor and the rising costs involved in the planting operation.

On an experimental basis, this planting aid did prove to be a labor saving device and 32 units were built for use in the 1971 planting season.

The previous planting systems employed at the Sugar Cane Growers Coop. were exclusively a hand-labor operation in which 2 men were used to move the continuous loaded short cane in the planting wagon into an apron basket located at the rear of the wagon. Three droppers walked behind the wagon and removed the cane pieces from the apron basket and dropped these pieces into the furrows. With the inclusion of the tractor driver and crew supervisor, 7 people were required for each planting crew. Three rows of cane were planted in one operation with this method.

With the new planting aid wagon, a mechanical means for moving cane from the wagon into the apron basket is utilized, thus eliminating the hand work involved in moving cane into the apron basket. Three droppers are still required to place the cane pieces into the furrows along with the tractor driver and crew supervisor to complete the 3-row planting operation. The planting aid wagons eliminated a very hard task along with 2 people from each planting crew as a total of 5 people are required per planting crew as compared to a planting crew consisting of 7 people required in the past.

MATERIALS AND METHODS

One of the main criteria in designing a planting aid unit was that it be capable of being used on the chassis of the existing infield harvesting wagons. Since the planting and harvesting seasons do not run concurrent, it was decided that this was the most economical approach to take. Therefore, the planting aid wagons were constructed in such a manner that they were used on the harvesting wagon chassis. The side tipping box or basket from the harvesting wagon was removed and the planting basket was attached for the planting operation.

The new planting aid wagon is a hydraulically operated unit powered by the towing tractor hydraulic system. A drag slat type conveyor covers the entire bottom of the wagon, and this conveyor consists of 4 chains with drag slats attached between the chains. A used continuous cane loader chain was used for the conveyor as an abundance of this chain was available. A light framed wall is affixed to the 4 strands of conveying chain, and this wall moves as the conveying chains are moved, which imparts a positive movement to the cane in the wagon. Two hydraulic motors drive the conveyor, and these motors are controlled through a hydraulic control valve located at the side and rear of the wagon. The movement of the cane is controlled by one of the cane droppers walking along with the wagon.

Since the green short cane used for planting is generally very trashy, the cane pieces are often tangled with trash, which prevents an even flow of cane to be conveyed into the planting apron basket on the rear of the wagon. To provide a more even flow of cane into this apron basket, a finger type rake is located across the top and to the rear of the wagon. This rake is powered by a single hydraulic cylinder and is used in conjunction with the conveyor to maintain a uniform supply of cane in the apron basket.

The rake moves a portion of the cane from the top of the wagon into the apron basket, after which the conveyor moves the bottom portion of cane into the apron; this process alternatingly continues until all of the cane is removed from the wagon.

This rake mechanism performs a double function in that it is also used to raise and lower the apron basket by the use of a pair of arms and chains on the rake which can be manually attached to the apron basket. Being able to hydraulically lift the planting apron basket into the loading position further eliminates the heavy work involved in the planting operation.

RESULTS AND DISCUSSION

The volumetric capacity of the new planting aid wagon is approximately 535 cu ft, which is slightly less than the capacity of the old planting wagons due to the space required for the conveyor in the wagon bottom and the addition of the wall. The planting aid wagon has a capacity of approximately 3-1/2 - 4 tons of seed cane, depending on the variety of the seed cane, the density of the load, and the amount of trash present.

In general, 3-1/2 - 4 tons of seed cane is sufficient to plant 3 rows 1/2 mile in length when the seed is double planted. However, when tripling the seed pieces in the furrows, there is not a sufficient amount of seed available in the wagons to make a full 1/2 mile through. In this instance, only 3 rows 1/4 mile long are planted before reloading the planting aid wagons to insure continuity in the planting operation.

The cost of the planting aid basket unit is approximately \$2,500.00, with the chassis being in the range of \$2,300.00. This brings the total cost of the planting aid wagons, complete, to approximately \$4,800.00 per unit.

From a production standpoint, 5,100 acres of cane were planted by this new method during the 1971 planting season. Two planting units were used and each unit was composed of 4 planting crews, with each crew consisting of 5 people, or 3 droppers, 1 tractor driver, and 1 crew supervisor or lead man. In addition to the planting crews, 1 hauling tractor driver and 1 continuous loader operator were used, which brought the unit total to 22 people.

During the 1st 5 weeks of the 1971 planting season, domestic labor was used exclusively in the planting operation, and the average production rate for planting was 5 acres per day per planting crew or a total of 40 acres per day for both units.

Due to the problems which existed in obtaining domestic labor, offshore workers were used for dropping cane for the remainder of the planting season and the production rate of planting increased to 11-1/2 acres per day per planting crew or a total of 92 acres per day for both units.

CONCLUSIONS

In general, the new planting aid wagon has proved to be a substantial labor saving device as two people have been eliminated from each planting crew as compared to the system employed in the past.

With the use of this new planting aid wagon, we have made a step forward toward mechanization of the planting operation; however, there still remains very much to be done before total cane planting mechanization can be realized. The planting aid wagons are just a very elementary advance in this area.

Looking forward, the Sugar Cane Growers Coop. has in preliminary design stages an experimental unit to further reduce the labor required for cane planting and it is hoped that in the near future some positive inroads can be made into this problem area.

PLANTING METHODS - SUMMARY OF PANEL DISCUSSION

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The final session of the October 12th meeting was devoted to a panel presentation and discussion of different planting methods. The compelling need to reduce manpower requirements wherever possible has focused attention on machine developments in both planting and harvesting. The following appeared on the panel: Joseph P. Sexton, Larry G. Fowler, Manuel Portuondo, and Otto Larsen.

Joseph P. Sexton, of US Sugar Corp., explained their use of planting boxes made to fit on the undercarriage of the harvest wagon. There are 4 rows of chains on the floor of the box, with slats spaced about 2 ft. apart between each pair of chains. The chains move the seed cane to the rear of the wagon and are powered by 2 hydraulic motors. Each box will hold enough cane to plant 6 rows, each 1/4-mile long. The seed cane is cut manually and loaded with the continuous loader. Planting crews consist of a foreman, 1 wagon operator and 3 seed droppers. There are about 37 crews who plant a total of about 240 acres a day. Covering is done mechanically with a rig that is also equipped to apply 2 lb of diazinon per acre in a liquid formulation for wireworm control.

Larry G. Fowler of the Sugar Cane Growers Coop. described their use of special planting wagons that fit on a harvest wagon chassis. These wagons have drag slat conveyors that cover the floor and a framed wall that moves with the conveyors and imparts a positive movement of the seed cane to the rear. Two hydraulic motors drive the conveyors. There is also a finger-type rake located across the top rear of the wagon. This hydraulically-powered rake moves a portion of the seed cane from the top of the wagon into the apron basket. Planting crews total 5 people, and 1 crew will plant 5 acres per day.

Manuel Portuondo, of Closter Farms, Inc., explained that whole stalks are placed into piles which are loaded with a grab loader into small planting wagons. About 2 tons are loaded into each wagon in a 2-wagon train. Two droppers riding the front wagon plant 2 outside rows and 2 droppers on the rear wagon plant the 2 inside rows. Men following the train cut the stalks into pieces 14-16" in length. The seed is covered mechanically and 20 lb of 15% Parathion per acre are applied for control of wireworms. Each planting crew plants 9 acres per day.

Otto Larsen, of Shawnee Farms, also uses the whole-stalk method of planting. The seed cane is hand cut, placed in piles and loaded crosswise onto the wagons with a grab loader. Three chains are installed on the floor of the wagon to move the seed cane to the rear. These are driven by a power take-off on the tractor which pulls the wagon. Four people drop the seed into furrows. Each wagon carries enough seed to double plant 4 rows 1/2-mile long. After the tractor operator has started the tractor in the furrows and adjusted the speed, he gets off the tractor and walks behind the droppers to see that the right amount of seed is dropped. After the cane is dropped, choppers cut the seed into short pieces and straighten it in the furrows. Covering is done mechanically with a 3-row rig on which insecticide hoppers have been installed to apply insecticide for wireworm control.

Following the panel discussion, there was a question and answer period.

Papers Presented at Meeting
of Louisiana Division

Baton Rouge, Louisiana
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STATUS OF THE DEVELOPMENT OF A WHOLESTALK CANE CLEANER

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INTRODUCTION

About one year ago the Hawaiian State Health Department gave the sugar industry 3 years to end all cane burning. The Chief of the Air Sanitation Branch of the Hawaiian State Health Department subsequently stated that he doubts that the sugar companies can comply with the 3-year time period. This mandate is probably the most drastic action taken against any sugar industry in the world in an effort to preserve the environment. However, the pollution outcry has been strongly evidenced to the Florida industry and pressure is mounting in Louisiana. Therefore, it is likely that burning regulations will be introduced, and waste control regulations for the Louisiana raw sugar industry will be in a state of flux during the next few years.

If one tried to accumulate reports on all the work that has been done in trying to remove trash from merchantable cane and then to write a book, it would be quite lengthy, even if it were limited to work done in Louisiana, Florida, and Hawaii. This book would necessarily include washing and dry-cleaning methods at the mill, as well as those methods that have been tried in the field or at transfer locations.

Trash has adverse effects on mill operations and field operations. Some of these effects can be defined, quantified, and put in terms of a cost to the grower or processor, while other effects are difficult to put in these terms. The processor's economic loss due to trash that is commonly referred to is based on a study reported 20 years ago by Keller and Shaffer (5). Some of the factors being adversely affected were listed as a lowering of mill capacity, extraction, and juice purities, while there were increases in power requirements, maintenance, and fiber. This list is not all-inclusive; however, the economic loss due to each 1% of trash was found to be equivalent to 1.85% of the value of the cane ground. While this figure has merit, its use is questionable for the type and quantity of trash that went to the mills this year.

In the last couple of years several papers at the ASSCT meetings have been devoted to trash or waste control at the mill, e.g. Gutekunst (4) and Seip (7). Also, reports have been made on the status of work being done for trash removal in the field, Clayton et al (1, 2). Numerous articles about cane cleaning have been written throughout the last 50-60 years. Several summaries of limited literature reviews on this subject have been made and two of the most recent are articles by Clayton and Roberts (1) and Lauden (6). Much of the work done during the last 10 years has been directed toward the removal of trash from chopped cane, e.g., Cochran and Clayton (3).

This paper is directed toward the wholestalk cane cleaning work that has been done in Louisiana during the last 2 seasons under the sponsorship of the American Sugar Cane League. This cooperative project includes personnel from the American Sugar Cane League, Cary Iron Works, L.S.U. Agricultural Engineering Department, and USDA, ARS, Sugar Cane Harvesting Investigations.

1970 SEASON

Wholestalk cane cleaning tests and demonstrations were conducted at the Leighton Mill in October using the USDA spiral-roll cleaner designed by J. E. Clayton. Results were reported by Clayton and Roberts (1). The Executive Committee of the American Sugar Cane League observed this machine in operation and agreed that further study and evaluation of roll types, and their associated variables, should be conducted by constructing a test stand. The experimental test stand was built by Cary Iron Works in Opelousas, Louisiana with the design being that of Mr. Russell Shafer and including ideas of the above mentioned cooperators.

Center-Spiralling Rolls. Initial tests were made with single pairs of cleaning rolls being used. Cane was fed parallel to the rolls throughout all of the following tests reported. The first pair evaluated was a set of 9-foot long center-spiralling steel rolls having a 5-inch pitch, 4-1/2 inch O.D. without the ribbon and a 5-1/2 inch O.D. with ribbon. Small samples, 15 - 65 lb, of frozen cane with tops were conveyed across the rolls using a pair of No. 80 sticker chains running above and adjacent to the rolls. Trash removal was on the order of 50% with about 10% cane loss experienced in these tests.

The use of pressure plates spaced 1-1/2 - 2 inches above the center spiralling rolls, and sticker chains running in recesses within the rolls such that the top of the sticker was slightly above the O.D. of the rolls resulted in about 50% trash removal and no cane loss. Based upon the earlier

unacceptable loss experienced and the costliness in making spiral roll modifications, it was decided that hexagonal shaped rolls should be evaluated further since these could be installed in a machine at much lower cost.

Hexagonal Rolls. The stock steel hex material from the Timken Bearing Company is 5.7 inches across the corners, 5 inches across the flats, 3/8 inch corner radius, and weighs 22 lb per foot of length. One roll of a pair is powered by a hydraulic motor, and the rolls are geared together such that the corners of one roll are timed with the flat side of the other roll. The hydraulic pump and orbit motor were powered with an electric motor. Roll speed, clearance between rolls, and the machine finish on the roll corners were varied. Two corner finishes were evaluated, the stock finish, and machining the corners down to 5.59 inches across the corners, which produces a uniform clearance between rolls.

Trash removal from topped stalks was best with the rolls operated at speeds from 450 - 600 rpm and with roll clearance of .040 inch or less. Cane loss increased with increases in clearance or decreases in speed, while trash removal decreased with increases in speed. The machined rolls appeared to be slightly superior with respect to cane loss. When the 9-foot long rolls were fed small samples of cane in single file, trash removal was consistently around the 50% level with cane loss 1% and less.

Three sets of machined hex rolls were next mounted in the test stand for further testing. A variable speed drive was provided for the cane conveyor. The conveyor consisted of two 6020 gathering chains. The table was also put on a 21° slope with cane being conveyed downward across the rolls, which had a .040-inch clearance and were run at 510 rpm. Various types of non-typical cane (green-house, crooked Grand Isle cane, frozen) were run in samples of 25 - 140 lb, and conveyed at chain speeds ranging from .7 - 1.1 mph. Trash removal varied from 40 - 74%, with the best cleaning occurring at the slower chain speeds. Feeding several samples across the rolls a second time resulted in 20-25% additional cleaning.

Further tests were run after finding some field cane that had not been severely frozen, although the trash was largely dry leaves. Comparing the 21° sloped to the horizontally positioned cleaning table revealed slightly less cleaning with 65% trash removal yielding 2.5% trash content on the mill cane and 79% trash removal yielding 1.8% trash content on the mill cane respectively, when the chain was operated at .7 mph. With the table horizontal and the chain operated at 1.4 mph trash removal was 73% yielding a mill trash content of 2.9%. As the cane was conveyed across the 3 sets, the first set typically took 60% of the trash that was removed and the second and third sets took about 20% each. It was anticipated that by increasing the slope on the cleaning table cane loss could be reduced; however, no significant reduction occurred and cleaning was not as good.

1971 SEASON

Most of the cane used in the 1970 tests had been frozen and the trash was practically all dry. Thus, it was desired to run some tests with green cane being conveyed across the 3 machined sets of hex rolls. The 1971 testing began in late July using immature CP 61-37 having average topped length of 4-1/2 ft and trash content before cleaning on the order of 20%. Tests revealed the rolls would remove 60 - 80% of the green trash and some small diameter, soft, top joints. Cane loss was higher than it would be for mature cane and generally was not recorded since the intent was to evaluate cleaning efficiency. Sticker chain conveyance was used for single layered cane and it was found that speeds greater than 3 mph caused significant decreases in cleaning. Nearly all of the tests subsequent to this have been run at 1.5 mph chain speed across rolls spaced at .040 inch and turning at or near 500 rpm.

A fourth set of rolls was added and positioned 14 inches below and 19 inches away from the last set, set 3, in the bed of the cleaner. This was added, along with a sheet metal ramp between this set and the bed, to evaluate the effects on cleaning by stair-stepping the cane down across these rolls. This set was evaluated in a horizontal plane and also at an angle of 21° with respect to the horizontal. This set was operated along with 2 of the sets in the table and found to give about the same cleaning as the 3 sets lying parallel in the bed. This set did remove more trash in the horizontal position than in the 21° sloped position. A set of spoked wheels was operated above this set to move the cane in a positive fashion across the rolls. Cane was conveyed across the bed by two 6020 gathering chains in these tests.

In an attempt to increase the capacity of the machine and make some tests with mat feeding, the gathering chain was altered to provide fingers that were 7 inches in length and 3 sets of chains were installed. These were operated such that the finger tips would run adjacent to the tops of the cleaning rolls and the 3 sets were spaced 18 inches apart and centered over the 9-foot rolls. Mats from 2 - 3 stalks thick were fed and samples 50 - 130 lb were used.

Less than 1% cane loss resulted with mat feeding; however, the cleaning efficiency was reduced -- 40 - 60% trash removal -- in comparison to single layer feeding. Varieties L 60-25, L 62-96, CP 61-37, and NCo 310 have been used in most tests. Pressure plates applied over the 2 operating sets in the cleaning table did not have a significant effect upon cleaning. When the trash consisted largely of leaves, the mill trash was typically 2 - 4% after cleaning. Crooked cane was found to feed reasonably well across the rolls; however, it was not generally cleaned as well as straight cane.

Corrugated sheet metal and industrial expanded metal were formed in several shapes and placed in the cleaning bed to try to get more agitation of the cane and loosening of the trash between operating sets. These did not show enough benefit to say there was a definite positive effect and were later removed to reduce the power requirements on the cane conveying system. Before these were removed, 2 tests were run with cane having a considerable amount of dry sandy loam and roots attached to the cane. Cleaning was found to be greater than 80% trash removal using the expanded metal placed flat and 70% removal using the corrugated sheet metal formed into a 3-inch high ramp.

Capacity estimates up to 50 tons/hr have been evaluated; however, for mat feeding it appears that 30 - 40 tons/hr is the maximum without having significant reductions in trash removal. A 25-foot long double-chain conveyor was constructed and attached to the inlet end of the cleaning table. The conveyor is now used to manually arrange cane on it in the manner desired for test purposes. This conveyor also has a variable speed drive. It has not been used to capacity yet; however, a number of tests have been made using samples of 240 - 260 lb.

Four sets of machined hex rolls have been installed in the bed and tested using CP 61-37 having 20 - 25% green tops. After cleaning, the mill trash was 4.3% with 50% of the trash removed. Only a small percentage of the tops has been removed by any of the configurations tested to date. The last set of tests was using wet, muddy CP 61-37 having 20 - 25% green tops. Trash removal, including mud, was again on the order of 50% with a 14% mill trash content resulting.

FUTURE

Based upon the interest in cane cleaning and the benefits that could be derived from this operation, there is little doubt that continued efforts need to be made in this area.

The present concept is to construct the cleaning machine as a piece of field equipment separate from the harvester, and to have the field capacity of a harvester. This machine would pick up the 3-row heap, thin the mat, remove trash, and expel the trash in the most desirable location. The cleaned cane could be handled or dropped in one of several ways.

What can be expected from this cleaning concept on a field scale basis for the many conditions of cane that occur and end up in the heap row? This cannot be answered specifically; however, the cleaning efficiency results have been favorable so far and there is reason to expect that such a machine can be justified on an economic basis.

While burning is still a very economical and generally satisfactory means to eliminate leaf trash, it is doubtful this will be allowed for too many more years. You have all read or heard in the news media of industries and agricultural enterprises having to shutdown or move in order to comply with one or more of the Environmental Protection Agency's pollution regulations. Let us all hope that the cane industry is able to comply with both water and air pollution regulations that are likely to be established over the next few years. Hopefully, these new regulations will not produce excessive stress on the pocketbooks of the grower or processor.

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CANE JUICE ACIDITY VS SUGAR RECOVERY

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This is a field-factory case study, attempting to correlate the effects of field operation/agronomical application that may influence the performance in the fabrication of sugar.

The acidity of cane juice was being used in the control of clarification until the pH measurement was adopted to take its place. However, the acidity is still being determined in Louisiana for the cane quality evaluation, particularly for a post-freeze or after other abnormal situations, such as fire, etc.

According to Irvine (1, 2), the main influence of acidity in the pre-freeze period is due to heavy soil. Other influencing factors are ratoon-stunting disease, maturity and freshness of cane. Also, the acidity increases when sugarcane is frozen. The acidity is determined by titrating 10 ml of juice with 0.1 N NaOH solution, using phenolphthalein as an indicator; and express the ml of NaOH solution as Total Acidity (4). Tables 1 and 2 were obtained from the mentioned references.

Table 1. Total acidity of juice vs soil types.

Cane varieties	Soil types		
	Lanaux (light)	Georgia (mixed)	Greenwood (heavy)
A	1.92	2.04	2.97
B	1.98	2.42	3.27
C	2.13	2.50	3.43
D	1.78	2.45	3.33
E	1.52	2.09	2.74

Table 2. Frozen cane vs total acidity of juice.

Type of juice	Variety and treatment			
	CP 61-37		L 62-86	
	Check	Frozen	Check	Frozen
Crusher juice	1.47	2.18	2.04	3.11
Mixed juice	1.14	2.68	1.53	2.97

However, this present study is confined only to those under normal, pre-freeze conditons. With 3 mills operated by the same company and located in different soil type regions, the opportunity for comparison was taken. Southdown and Greenwood are in the heavy soil regions, while Armant is in the light soil area. The daily acidity of normal juice of these 3 mills during the 1971 grinding campaign are shown in Fig 1.

This confirms the results found by Irvine, that the juices from heavy soil regions do give higher total acidity.

Now, if this is the main cause, then by modifying the physical property of the soil could we expect also the change of acidity? There was the opportunity to compare several plots with and without bagasse conditioning.

In 1970, about 50 acres of heavy soil was conditioned with bagasse at the rate of 10 tons/acre. The bagasse was spread fairly evenly, then the field was chopped to mix the bagasse with the soil.

Cane samples from adjacent plots, with and without bagasse conditioning were taken. The three plots assigned for this study are within a distance of 500 ft., with similar environment, except the difference in bagasse and cane variety. Results of analyses are shown in Table 3.

Table 3. Juice characteristics vs soil conditioning.

Test Series	Quality characteristic	Soil conditioning and variety		
		With bagasse	Without bagasse	
		L 60-25	L 60-25	CP 61-37
1203	pH	5.5	5.5	
	Acidity	2.4	2.5	
	*Lime milk, ml	82.0	98.2	
	pH after boiling	6.9	6.7	
1206	pH	5.45		5.35
	Acidity	1.9		1.9
	*Lime milk, ml	85.0		92.5
	pH after boiling	6.7		6.8
1210	pH	5.4	5.45	5.4
	Acidity	1.9	2.3	2.4
	*Lime milk, ml	87.5	116.0	110.5
	pH after boiling	6.7	6.85	6.8
1214	pH	5.4	5.4	5.4
	Acidity	2.0	2.6	2.2
	*Lime milk, ml	98.3	106.0	110.0
	pH after boiling	6.9	7.0	6.95
1218	pH	5.4	5.5	
	Acidity	2.2	2.4	
	*Lime milk, ml	98.6	103.5	
	pH after boiling	6.65	6.75	
Average with corresponding pairs	pH	5.4	5.5	
	Acidity	2.13	2.45	
	Lime milk, ml	91.6	105.9	
	pH	5.4		5.4
	Acidity	1.93		2.17
	Lime milk, ml	90.3		104.3

* Per 250 ml juice, with pH meter to pH 7.8

It can be seen that pH bears no constant relation with the acidity by titration. Also there is no relation between titration with NaOH and milk of lime. In order to predict the effect of acidity to the factory liming operation, it would be more meaningful if it is titrated and expressed with milk of lime instead of NaOH.

By using the figures of lime titration, we can calculate the lime consumption to obtain the following comparison (Table 4).

Table 4. Lb of lime required/ton cane (calculated from lime titration), and cane yield.

Test series	Soil conditioning		
	With bagasse # 1	# 2	Without bagasse # 3
1	1.16	1.39	
2	1.37		1.49
3	1.56	2.05	1.96
4	1.42	1.54	1.59
5	1.59	1.67	
Average with corresponding pairs	1.43	1.66	
	1.45		1.68
Cane yield, ton/acre	30.89*	21.32**	

* Of 15.5 acres.

** Of 20.3 acres, nearby to the test area.

The preliminary results indicate that the bagasse conditioning could reduce the juice acidity and also increase the yield of cane.

The actual consumption of lime in the 3 mills also show the distinctive difference in the heavy soil and light soil regions (Table 5).

Table 5. Lime consumption, lb/ton cane, during 1971 grinding campaign.

Period	Location		
	Houma	Greenwood	Armant
1	13 days 2.33	19 days 2.35	12 days 0.97
2	30 days 1.88	14 days 2.02	14 days 1.22
3	29 days 1.98	8 days 1.77	14 days 1.05
4		6 days * 3.10	14 days 1.04
5		18 days * 2.65	14 days 1.09
Crop average	1.97	2.33	1.08

* Due to high trash and field earth, more lime was used for reliming clarifier mud, and for some high acidity juices (acidity 3-4).

When checking these figures with the curves shown in Fig. 1, they show the coincidental tendency of lime consumption as a function of juice acidity.

With higher consumption of lime, there will be more sugar being brought along, with lime salts, to the final molasses. This is well known in the technology of sugar fabrication. Now by using the figures of McGinnis (3), and the figures of Houma and Armant in Table 5, the additional loss of recoverable sugar amounts to an equivalent of 0.9 gal (80° bx)/ton cane, or 4 - 5 lb sugar/ton cane. This range checks well with the current difference in performance between Houma and Armant.

SUMMARY AND COMMENTS

- 1) This is an observation of one of the factors related to both agronomical and factory operations, under pre-freeze conditions.
- 2) It is indicated that the physical property of soil affects the total acidity of juice.
- 3) The application of bagasse into the heavy soil indicates promising results for reducing the juice acidity, in addition to the increasing of cane yield. This is an area that the cane researcher should get into.
- 4) The acidity of juice increases lime consumption, and the increased lime salts will bring along additional sucrose to final molasses. The economy of conditioning the soil with bagasse will depend on the evaluation of:
 - a) additional cost of lime.
 - b) additional loss of recoverable sugar to final molasses.
 - c) increase of cane yield.
- 5) To make the acidity more meaningful, as related directly to factory operation, it is recommended that the titration should be made and expressed on lime solution instead of NaOH solution. This is also a new area for the cane researcher to get into.

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WHY?

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This paper holds promise to be the least technical and scientific paper presented in the history of the ASSCT.

Are the cane grower members of St. James Factory different? Why did they average as a group 32.1 gross tons per acre and 31.0 standard tons per acre. Why? The yield range was from 21.9 - 41.1 tons per acre standard. Reports coming to us speak of 19 - 22 tons per acre range and an occasional 25 - 26 ton yield. Agreed, that there are geographical differences, soil differences, weather differences, but are these significant differences? It is true that the effects of Hurricane Edith left in its wake varying degrees of damage to the cane crop as one moved about the sugar cane area. Let us examine the rainfall behavior. Recorded rainfall at St. James Factory showed a total of 18.06 inches from January through June, with 4.31 inches in March for the high and .31 in April for the low. Then came the monsoon season - 11.30 inches for July, 9.58 inches for August, 13.25 inches for September. Very little cane was planted until the end of September. Most of the cane was planted during grinding. From the rain record one can see that we moved from a very dry period to a long wet period. We could not have had our planned program more upset.

Could it be land preparation, precision grading, improved water control, deep plowing to break the hard pan, multi-row land preparations, cultivating and spraying equipment? Everyone does all these things in some degree and has such equipment. Could it be variety selection for principal commercial application? Our people, too, have used profanity in reference to L 60-25 and CP 61-37. While that goes on, some of our growers had good results with CP 61-37 in yield and sucrose and all had good sucrose in L 60-25.

Could it be soil testing and the resulting application of lime, phosphate or potash or all three as needed? What about control of RSD by heat treating? How effective is the mosaic control program? Has the borer control program been carried out in a manner that resulted in effective and efficient control of the cane borer? Then there is the all important weed control program.

Without question, this was a difficult harvest year. Fortunately, October and November were in the good weather cycle, or harvest conditions would have been worse in that period. Recorded rainfall for October and November was 1.83 and 1.82 inches, respectively. But on December 1, rains started, and in our growing area rainfall for December ranged from 7-15 inches. The condition of fields, roads, etc. after the harvest is one of the worst to be recalled in modern mechanized times. Throughout the harvest most of the cane was harvested by cutting one way only. CP 61-37 in many instances could only be harvested by burning before cutting.

To place things in perspective, before going to the factory we should repeat an old 1862 saying, "Sugar is made in the field-not in the factory". The factory's only function is to convert the combined efforts of nature and man into marketable form.

Now, how did St. James Factory fare in this most difficult year? Once during the season the sponsoring bank (sponsoring bank is the bank that lends us money) asked us why were we recording such results on our reports. A quick answer was "good management". That was okay until the bank questioned about a couple of past years to which we responded "Acts of God". Needless to say the bank was not overly impressed.

From the beginning of grinding until the rains came in December we were faced with inadequate supply of cane to maintain rates of grind at or near capacity. This resulted in absolutely fresh cane being delivered, and did not permit cane aging in fields or factory cane yard. This was especially important this year because of the unusual hot weather encountered. The high temperatures started quality deterioration after cutting, at an even more rapid pace after burning and at an almost unbelievable rate in the pile at the cane yard especially if the cane had much mud. Lab analysis on crusher juice from muddy unburnt cane carried over one day under our derrick in the cane yard showed a purity drop as much as 4 points during a 12-hour period.

We have reason to believe cane of poor quality was subjected to more rapid loss in higher piles under derricks and overhead crane under these high temperature conditions. Indications are that the lower storage piles in cane yard placed by front end loader (Supple System) at an average height of 13'-0" did not result in such high purity losses.

Actual weighings and calculations of our Supple System indicate 222.05 lb cane per sq ft, or 17.08 lb of cane stored per cu ft. As an aside, one front end loader was used at St. James Factory and the results were beyond the most optimistic expectations. One unit of comparable size has no difficulty storing and/or feeding at over 4800 tons/day. Actual weighings of grab load ranged from 10-12 tons, far in excess of

earlier estimates of 6 - 8 tons. We believe these weights are excessive and should not be expected or recommended. However, for many reasons, capacity, versatility, mobility, ease of operation just to name a few would cause us to recommend the "Supple System" without qualification.

Now we must ask the question what have we caused by way of losses even before we place the cane in the carrier?

We believe cane yard management in cleaning the cane yard every day under any condition and especially during high temperatures is the First Commandment.

Cane washing. Even inadequate washing is important. Serious clarification and bagasse burning problems can be minimized by proper cane washing. The revised cane washing system at St. James, although somewhat inadequate, was very helpful during the past season.

The milling tandem handled its assigned 292,000 tons with little trouble and did a satisfactory job of mill work according to our sucrose in bagasse and brix curves. There were times when the quality of cane left much to be desired; but this was one of those years. No mill rolls were changed during the season. On one occasion, cush-cush became excessive at the last mill and required a turnplate change at about 200,000 tons. We found that damage to this turnplate was caused by a wedged snatch cable. We must point out that our mill groovings are 3" for first unit, 2 1/2 for second unit, 2" for 3rd & 4th with last being 1 1/2". All top rolls have deep hook grooving. We maintained a rigid program of mill housekeeping calling for hot water hosing of the mills every 12 hr. Even with that, bagasse that was in inaccessible places would sour in short time in the hot weather that stayed with us throughout. In addition we used a mill biocide.

The steam generation plant called for constant surveillance due to condition of bagasse and the awareness of potential natural gas shortage. On several occasions bagasse burning was associated with problems. In spite of this, all the bagasse was burned in the boilers--no excess to blow out--and natural gas consumption per ton was reduced 21%.

The most significant change in the boiling house was the modification of the evaporators. Having to push the evaporators is necessary at St. James and in the past showed evidence of entrainment. A modification resulted in correcting this situation and a recovery of .5 lb sugar was sufficient to finance this condition.

The grinding rate was adjusted to that quantity that could be handled in the clarifier and filter station. St. James produces a 99° pol sugar and must have very good clarification. At times the grinding rate was reduced to as little as 60% of normal; however, for the crop we attained 85.5% of the accepted norm. Our filters are cloth covered and have been so operated for several years. At intervals it was necessary to ditch mud. This action was only taken by superintendents with management's knowledge, and a log was maintained as to the amount and sugar losses due to the ditched mud. Ditching of mud, if not tightly supervised, can result in excessive losses and/or substantially reduced sugar yield. We found it necessary to ditch mud in one of three clarifiers for short intervals totaling 12 hr in 20 days because of limitations at the filter station.

The entire season was pressure packed. Cane supply - cane quality - high trash and excessive soil in cane - problems associated with bagasse burning - clarification - low grinding rate - low sugar yield. Aside from these few adversities and others too numerous to list, this was a normal season.

Then why did St. James achieve one of the better results in sugar yield? Was the cane supply quality better? We do not believe. Is St. James better? St. James is one of the good factories, but St. James has never been first and like Avis maybe we tried harder.

What part did good cane yard management - good housekeeping - improved cane washing - tight control over the house - grinding rate geared to capability of good clarification have in these results? What improvement did evaporator modifications have? We believe all of these contributed in total, and we are unable to grade any one single item.

One item that has some disturbing effects upon the growers and processors is the method of determining the quality of cane. The trash and sucrose tests and the DCF determination are at best averaging evaluations. Circumstances beyond human control can have violent effects upon these averages. Certainly, there should be enough expertise available to develop and implement a more positive program related to true realizable values.

But, we believe one ingredient was equally if not more important and that is - communications.

In the early summer it became apparent that a natural gas shortage was upon us for this winter. In order for all of our people to understand the seriousness of the gas problem we held conferences of our management, engineering and superintendents along with the sugar boilers and steam generating plant foreman. The point was to have everyone related to operations aware of the importance and seriousness of natural gas consumption. Immediately, each one in the conference realized the meaning of possible natural gas curtailment and offered suggestions as to how gas consumption could be reduced. These conferences led to further offerings of gas conservations and branched into possible steam conservation, and water conservation.

The dialogue was started and excellent communications and understanding existed between our people. For example, if water was short for a spell, steps were immediately implemented to conserve on water. The cooperation in times of low steam was unbelievable, and the natural gas consumption program resulted in reduction per ton when the trend generally was up and of course there were savings. This has worked well and a series of conferences is set to see what can be done to further improve in these areas for the coming season.

In summary many things can be done to plant but we must never overlook the important area of communication. As important as this is in the factory operations, communications between factory and growers is no less important.

PERFORMANCE OF THE SCREW PRESS AT
CORA-TEXAS SUGAR FACTORY

Jose G. Spinoso
Cora-Texas Manufacturing Co.
White Castle, Louisiana

(This paper was also presented at the joint meeting of the Florida and Louisiana Divisions at Pensacola, Florida in 1972 and is printed in that section of the current volume).

THE 1971 CROP AUDUBON SUGAR FACTORY STUDIES

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ABSTRACT

The following five 1971 crop senior chemical engineering student research projects were sufficiently timely and conclusive as to warrant summarizing the investigations: (1) cane sampling by coring, (2) closed loop cane washing, (3) sucrose/pol vs variety and purity, (4) brix by refractometer, and (5) optimum mud filtration parameters. The results in summary are: with a simple vertical (or horizontal) core sampler, problems are encountered in obtaining reproducible results with whole stalk cane containing a high volume of immature top sections--typical of Louisiana cane. Total recycle of cane wash water to minimize impounding area is practicable with normal provisions for biocide addition at the mill. Chlorine addition may be necessary for odor control. The relationship of sucrose/pol appears to be purity rather than variety dependent. The moderately priced brix refractometers reading to 0.2° brix show good accuracy and reproducibility over the range of factory streams. With juice containing a high volume of suspended solids, they are far superior to the hydrometer. When handling dilute, hard-to-process muds, optimum filtration parameters include high temperature, 7.0 to 7.5 pH, about 150 ppm coagulant and up to 5.0% bagacillo on muds.

INTRODUCTION

Besides serving the Louisiana raw sugar industry as a center for processing research, the Audubon Sugar Factory continues to provide practical training for chemical engineering students. Capable of processing 20 tons of cane per hour, the factory and associated pilot plant raw sugar and byproduct facilities duplicate many of the unit operations and processes of a typical chemical process industry.

While numerous developments have occurred in the areas of automation, mathematical modeling, and computer techniques, the chemical engineer must still rely on empirical methods involving judgement, based on experience and observation as well as theoretical considerations. For this reason, the factory facilities have provided an ideal supplement to the more conventional lecture-oriented material. In particular, the senior student course ChE 161 presents the factory as an analogue of a typical chemical process industry. The first half of the course is devoted to lecture and laboratory work covering the phases of unit operations, equipment performance and testing, chemical control, and economics of a chemical process operation. For the remainder of the course, the students are divided into groups and assigned research projects covering areas of current importance to the industry. In these projects, the students are assisted by members of the faculty, graduate students, and factory personnel. As might be expected, the results of some of these studies have been of immediate interest and have been previously documented (6). Of more current interest, the results of the following five 1971 projects were sufficiently conclusive as to warrant publishing the scope and results of the studies:

- Cane sampling by coring
- Closed loop cane washing
- Sucrose/pol vs purity and variety
- Brix by refractometer
- Optimum mud filtration parameters

CANE SAMPLING BY CORING

Rainy, muddy harvesting conditions contributed to a high volume of trash and field soil accompanying the cane to the factory. This situation again pointed up the inadequacies of our current method of cane sampling and evaluation for cane payment. This system entails the determination of trash in a cane consignment, the evaluation of juice quality, and the subsequent expression of cane quality in terms of standard tons. Trash is determined from 60 - 100 lb of cane which are removed from the feeder table by means of a mechanical grab. For juice quality, several stalks of cane may be removed from the trash sample--or they may be manually secured from the vehicle--and subsequently milled in a sample mill. By means of the trash data, gross cane is converted to net cane. By means of factors, the sample-mill juice analyses are converted to normal juice sucrose and purity. From these data, net cane is converted to standard cane--the basis for subsequent payment.

Briefly, the key ingredients of a successful cane sampling and evaluation system should include the elements of:

- Removal of the sample
- Preparation of the sample for processing
- Processing of the sample
- Analyses of the sample
- Expressing the analytical data in meaningful cane quality terms
- Sample data which supplement the factory chemical control system

A revival of interest in core sampling has been sparked by the development of the C.A.P.S. system (France) and the J & L Engineering Company (a HONIRON subsidiary) line of core samplers. The C.A.P.S. system (4) is being used in Guadeloupe, Martinique, and being considered in Reunion. This system entails removal of a core sample from the cane conveyance, attriting the sample in a small crusher or shredder-type device, weighing and processing a subsample in a hydraulic vertical cylindrical press, weighing the bagasse residue and calculating the cane quality in terms of predicted recoverable sugar per ton of cane. The J & L system (3), currently in operation in Puerto Rico, also involves removal of a sample of cane by means of a core sampler and attriting the cored material. However, the analysis is performed by the conventional cold digestion method.

This fall we reactivated the LSU corer sampler. The initial development of this equipment was a cooperative project of the Louisiana industry, the USDA, and Louisiana State University starting in 1956. The equipment consists of a vertical corer under the feeder table platform with a 6 in. bore and 6 ft 8 in length traveling upward into the bundle, which rests on a dolly on the feeder table platform.

In our studies, 2-ton bundles of cane were core sampled at various locations in the bundle. The core samples were composited and triple milled in a hydraulically loaded 3-roll mill (12 in. dia x 12 in. long rolls). The sampled bundles were then processed through the factory milling tandem, which consists of a 2-roll crusher and three 3-roll mills (18-1/2 in. dia x 24 in long rolls); 20% maceration water was applied to the tandem. Core and factory juice and bagasse were weighed and analyzed. All cane consignments were unburned and contained a high percentage of extraneous material.

The comparative factory and core sample results are shown in Table 1.

Table 1. Cane sampling by coring: core sample vs cane consignment.

Parameter	Run									
	PP-2		PP-3		PP-4		PP-5		PP-6	
	Factory	Core	Factory	Core	Factory	Core	Factory	Core	Factory	Core
Trash % cane	14.42	-	-	-	12.37	-	24.45	-	29.66	-
Weight of cane, lb	1975	20.6	3020	22.0	2841	15.6	5280	27.6	4932	24.9
Maceration % cane	33.72	0	26.46	0	35.13	0	33.26	0	30.37	0
Mixed juice % cane	93.42	58.74	90.89	60.45	98.35	56.58	97.18	64.49	95.66	61.45
Bagasse % cane	40.30	41.26	35.56	39.55	36.78	43.42	36.08	35.51	34.71	38.55
Brix % cane	14.08	14.66	15.17	13.71	15.38	14.16	13.25	13.74	12.41	12.49
Pol % cane	10.71	12.14	11.05	10.50	11.72	11.18	10.45	11.68	10.09	10.41
Fiber % cane	17.30	17.10	13.78	14.36	15.75	15.46	15.44	13.98	14.76	15.75
Mixed juice purity	76.03	82.98	73.48	76.64	77.20	78.98	79.06	85.02	81.61	83.34

For discussion, primary consideration is given to pol and fiber % cane. As indicated by the data for the first run (PP-2), a basic problem immediately arose as to where to remove the sample. In this run, samples were removed in close proximity to the 2 chains, as this was the recommendation of previous studies (5). Very high core sample vs factory pol is evident. In PP-3, 2 additional samples were removed to include the tops at each end of the bundle. The results were now reversed with a low sample vs factory pol. In subsequent runs, 3 samples were removed from the one side of the bundle only--to include tops, middle, and bottom. Results were better, but still lacked a high degree of correlation.

With regard to fiber % cane, the results were not as sensitive to core location. Probably only PP-5 showed an extreme variance between the factory and sample fiber.

From these studies, it appears that under Louisiana conditions obtaining a representative sample of whole stalk cane with a high volume of immature top sections is a real problem with a simple horizontal or vertical corer. A different situation may exist with a corer slanted to the perpendicular and diagonally traversing the cane consignment from the upper right to lower left or vice-versa--or with randomly loaded or cut-chop cane.

A cooperative program of further studies in 1972 is being developed among the industry, the J & L Engineering Company, and the Audubon Sugar Factory.

CLOSED LOOP CANE WASHING

Heavy rainfall and attendant muddy cane posed a real problem in this crop. Superior cane washing facilities were barely adequate, so-called adequate facilities could not cope with the volume of field soil accompanying the cane to the factory, and those factories without washing facilities were faced with an almost impossible situation.

An essential ingredient for the conventional cane washing system is adequate area for impounding the spent wash water for stabilization prior to discharge to public waters. One expedient to reduce impounding area from a water volume standpoint has been to partially recycle spent wash water from beneath the feeder table to cane on the table. Thus a factory using 4,000 gpm may bleed in 1,000 gpm fresh water and pump to impounding approximately the same amount.

A severe shortage of available area for impounding may deny a factory even this expedient. For this reason, the completely closed-loop cane wash water recycle system at Alma Factory offered an unique opportunity to investigate such a scheme. The total impounding area occupies about 8 acres and includes:

- A sedimentation canal
- A sedimentation pond
- A clear water pond

The Alma installation is depicted in Fig. 1. The distances are approximate, having been paced off. High ground in the center of the sedimentation basin gives this section a horseshoe configuration.

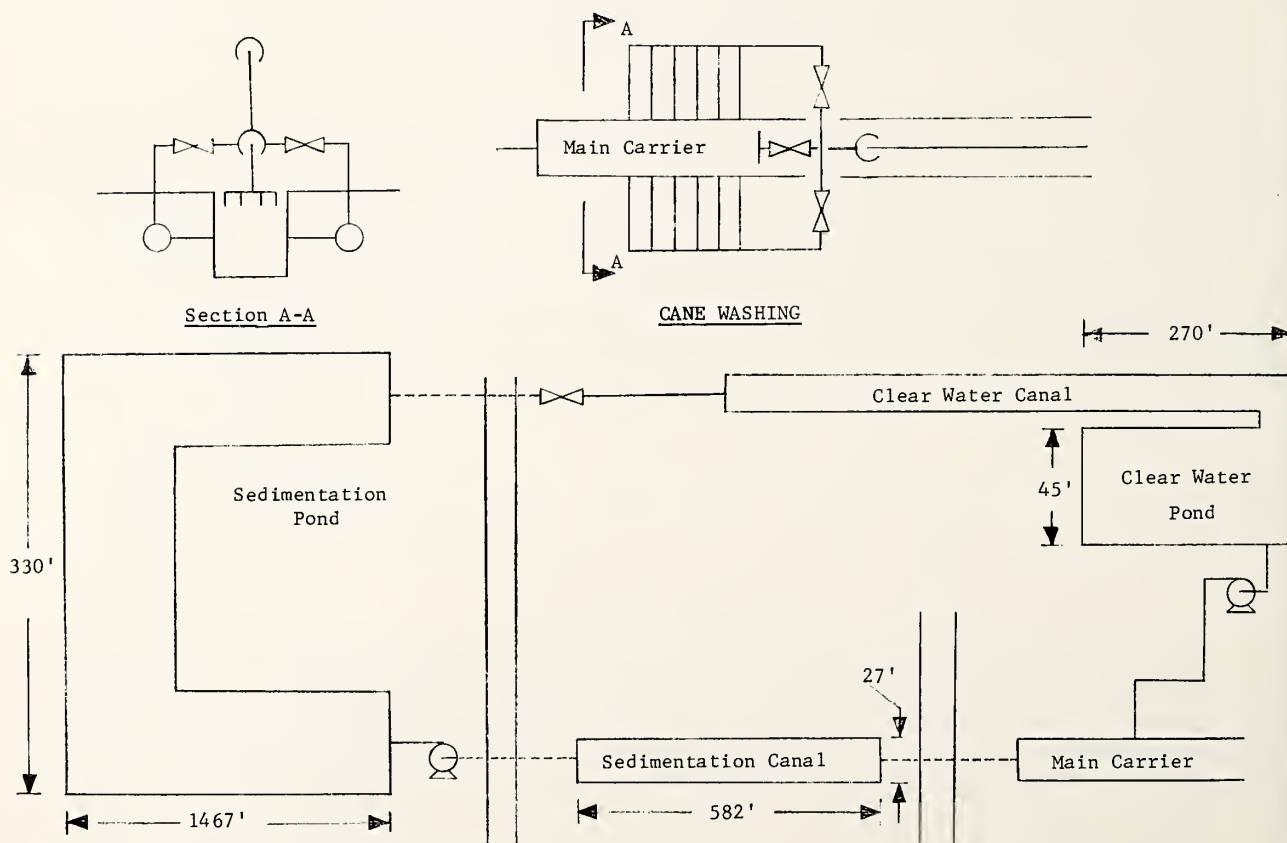


Fig. 1 Closed loop cane washing system at Alma factory.

The study entailed collecting wash water samples and mill juice samples. Wash water samples to and from the carrier--and at intermittent points within the system--were analyzed for pH, alkalinity, COD, and microorganism count. Crusher and mixed juice inspections included brix, pol, purity, reducing sugar, and microorganism count for the mixed juice only. Considerable difficulty was encountered by the students in acquiring proficiency with several of the analytical techniques. The microorganism counts were difficult under any circumstances, and for assistance in this aspect we are deeply indebted to the Microbiology Department in general and to Arthur A. Colmer in particular.

Table 2 shows data well into the crop for December 9 and 14, when we felt that the procedures were well established. Several wash water inspections were omitted since some of the students were not available due to semester final examinations. In this series of runs, a comparison was made between Alma with a closed-loop system and a nearby factory, Factory B, which used well water feed and a once-through pass to the impounding system. Both factories use a biocide at the mill. The December 9 data show crusher and mixed juice analyses of 6-hr juice composites. The December 14 data include the above plus microorganism counts of the wash water to the carrier and the mixed juice from the tandem.

Table 2. Cane washing: closed loop vs once-through at 2 factories, Alma and Factory B.

Wash water		Juice		Juice	
to carrier		Crusher	Mixed	Crusher	Mixed
Alma	B	Alma		Factory B	

12/9/71

Juice composite analyses

Brix	12.03	12.08	11.50	11.20
Pol	9.42	9.30	9.24	8.96
Purity	78.30	76.79	80.35	80.00
R.S.	0.901	0.928	0.699	0.676
R.S. ratio	9.56	9.98	7.56	7.55

12/14/71

Juice composite analyses

Brix	12.53	12.00	13.50	11.86
Pol	9.98	9.33	10.81	9.30
Purity	79.97	77.75	80.07	78.41
R.S.	0.930	0.862	0.860	0.800
R.S. ratio	9.32	9.24	7.96	8.60

Microorganisms

Total Count, per ml	1.00×10^6	<300	-	2.24×10^7	-	2.38×10^7
Leuconostoc, per ml	1.68×10^5	<300	-	1.26×10^7	-	1.12×10^7
Yeast, per ml	3.20×10^3	<300	-	8.40×10^5	-	4.75×10^5
Coliform, per ml	6.40×10^2	0	-	1.30×10^6	-	3.30×10^5

While the December 9 increase in R.S. ratio from mixed juice to crusher juice is relatively high for Alma as compared to Factory B, the reverse is the case for December 14. As would be expected, the microorganism count for the Alma recycle inlet wash water to the carrier is high. The figure for the once-through well water to the feeder table at Factory B is obviously low. Of particular interest is the fact that the microorganism count of the mixed juice is roughly of the same order of magnitude for both Alma and Factory B. The coliform count is slightly higher for Alma. The near equality of the crusher and mixed juice brix at both factories may reflect the wet muddy conditions prevailing at the time of the test, the relatively large volume of wash water which accompanies trashy cane into the factory, and the practice at both factories of returning crush-cush before the crusher.

No incipient juice infection was evident at Alma. Boiling house problems were common to those of all factories in the area. Sugar was of apparent good quality and the factory yield approximated that of neighboring factories. Odor was a problem on warm days. It was particularly pronounced in the area of the clear water pond. In populated areas it might be necessary to consider the use of biocides or chemicals (as chlorine) in the wash water, or floating aerators in the clear water pond.

Based on these preliminary results, the closed-loop cane wash water system appears practicable. More investigations are planned in 1972.

SUCROSE/POL VS PURITY AND VARIETY

A recent paper by Chen et al (1) discussed the implications of the difference between juice pol and sucrose in the evaluation of cane for payment and for varietal evaluation. Rather extensive analytical data cover pol and sucrose by variety as well as the reducing sugars in general and dextrose and levulose in particular. The paper rightly observed that simple pol determinations reflect other optically active substances in solution. Among other things, the investigation shows a significant

difference between pol and sucrose among varieties. Particularly of interest were the data for CP 52-68 (a late maturing variety) and L 60-25 (an early maturing variety).

Irvine's subsequent studies (2) cover gas-liquid chromatographic inspections of unleaded juice for the dextrose/levulose ratio. He reported that the new, early-maturing, high-purity varieties have a lower D/L ratio than the late maturing varieties. To the contrary, the older, late-maturing varieties show a higher D/L ratio.

A review of the preceeding studies indicated that purity rather than variety might be a critical factor in the relationship of sucrose to pol. Thus, one of the slower maturing varieties as CP 52-68 might be expected to show the same sucrose to pol ratio at a comparable purity as say L 60-25, an early-maturing cane. For the Audubon Sugar Factory tests, cane samples from various areas of the state were supplied by Mike Giamalva, Head, Outfield Sugars.

Prior to milling, all foliage was removed from the samples. In addition to the usual juice analyses, Clerget Sucrose and reducing sugars (R.S.) were determined. Clerget Sucrose is a time consuming operation. This fact and the problem of securing cane samples during inclement weather limited the scope of these studies--as to the number of observations, the number of varieties investigated, and the fact that only stubble cane was analyzed.

Table 3a shows the purity-variety-sucrose/pol ratio for 4 varieties. The data are arranged in order of descending purity.

Table 3a. Sucrose/pol ratio by variety and purity.

Sample no.	Purity		Variety											
			CP 52-68			L 60-25			L 65-69			L 65-357		
	Appar	True	Suc	Pol	S/P	Suc	Pol	S/P	Suc	Pol	S/P	Suc	Pol	S/P
SM-2	91.01	91.45	-	-	-	18.93	18.82	1.006	-	-	-	-	-	-
SM-4	85.14	86.91	-	-	-	-	-	-	-	-	-	17.66	17.30	1.021
SM-6	83.85	85.16	-	-	-	18.14	17.86	1.016	-	-	-	-	-	-
SM-1	83.73	85.83	16.41	16.01	1.025	-	-	-	-	-	-	-	-	-
SM-3	81.15	84.58	-	-	-	-	-	-	16.56	15.89	1.042	-	-	-
SM-8	68.10	74.33	-	-	-	-	-	-	-	-	-	15.87	14.54	1.091
SM-5	67.95	72.26	14.09	13.25	1.064	-	-	-	-	-	-	-	-	-
SM-7	48.00	58.39	-	-	-	-	-	-	12.89	10.58	1.216	-	-	-
SM-14*	21.83	33.29	-	-	-	2.47	1.62	1.525	-	-	-	-	-	-

*Sm-14: L 60-25 tops (section from two formed joints below the bud to immediately above top mature joint).

It will be noted that the values of sucrose and pol are almost identical at high purities, with the ratio of sucrose/pol approximating 1.00. As the purity decreases, the sucrose becomes increasingly greater than the pol--with sucrose/pol ratios increasing correspondingly. Here there appears to be no variety effect, although CP 52-68 was the only older variety investigated. In effect, cane maturity as indicated by juice purity appears to be a primary factor.

Table 3b shows the relation of purity-variety-reducing sugar (R.S.) ratio. As would be expected, as the purity decreases, the reducing sugar ratio increases.

Table 3b. Reducing sugar ratio by variety and purity.

Sample no.	Purity		Reducing sugar ratio for varieties			
	Appar	True	CP 52-68	L 60-25	L 65-69	L 65-357
SM-2	91.01	91.54	-	2.18	-	-
SM-4	85.14	86.91	-	-	-	6.94
SM-6	83.85	85.16	-	n.a.	-	-
SM-1	83.73	85.83	7.43	-	-	-
SM-3	81.15	84.58	-	-	10.20	-
SM-8	68.10	74.33	-	-	-	32.05
SM-5	67.95	72.26	30.26	-	-	-
SM-7	48.00	58.39	-	-	76.47	-
SM-14	21.83	33.29	-	125.0	-	-

A subject of prime interest would have been the dextrose/levulose ratio for the same samples. Unfortunately, time and equipment requirements did not permit such determinations.

BRIX BY REFRACTOMETER

The heavy rainfall during much of the harvest and the attendant high volume of field soil entering the factory with the cane posed a real problem in determining soluble solids or brix by the conventional hydrometer. Where the volume of suspended material in the juice was sufficiently high, even settling of the material in the hydrometer cylinder was inadequate. In such cases, it was necessary to settle the material in a large container and syphon off or decant the settled juice to a hydrometer cylinder.

The high precision refractometer has been used for control in Hawaii for many years. While readable to 0.02° brix, the cost of the instrument has precluded its general use in other areas. The old Abbe refractometer, calibrated to 0.5° brix, has not been sufficiently accurate for control use. In recent years, moderately priced refractometers reading 0.2° brix and capable of interpolation to 0.1° brix have appeared on the market. These instruments are now being used for factory control and cane sampling in many cane growing areas.

For our studies, we used a Schmidt & Haensch sugar refractometer 0-80° brix range and readily interpolated to 0.1° brix. The accuracy of the instrument was first determined by comparison with standard pure sucrose solutions and a set of standard brix hydrometers. Further studies were conducted with the factory process streams normally encountered in routine laboratory control. As a final phase of the investigation, refractometer and hydrometer comparisons were made with juice containing a high volume of suspended solids.

Table 4a shows the results of the comparison among standard sucrose solutions, standard brix hydrometers, and the refractometer. Eight separate hydrometer and refractometer determinations were made of each sucrose solution and the average and standard deviation determined.

Table 4a. Refractometer brix: comparison of standard sucrose solutions, standard brix hydrometers, and the refractometer.

% Sucrose	Average of 8 readings		Standard deviation	
	Refractometer	Standard hydrometer	Refractometer	Standard hydrometer
8.26	8.25	8.19	0.0925	0
11.23	11.15	11.21	0.0679	0
15.18	15.26	15.06	0.0433	0.0259
18.03	18.08	18.07	0.0107	0.0220
25.51	25.69	25.49	0.0084	0.0446
35.30	35.58	35.38	0.0426	0.0330
45.34	45.64	45.65	0.0553	0.0659
55.81	56.09	-	0.0660	-
66.05	67.28	66.04	0.1640	0

Generally good agreement is noted. To provide a "feel" for the spread of the readings, Table 4b shows the replicate refractometer readings for the 11.23 and the 35.30% sucrose solutions.

Table 4b. Refractometer brix: refractometer precision or reproducibility.

Observation no.	Solution--% sucrose	
	11.23	35.30
	reading xi	reading xi
1	11.26	35.63
2	11.16	35.59
3	11.06	35.49
4	11.06	35.59
5	11.21	35.54
6	11.16	35.59
7	11.16	35.59
8	11.16	35.59
Ave,	11.15	35.58
Standard deviation	0.0679	0.0426

Table 4c shows the comparative averages and standard deviations for 8 replicate hydrometer and refractometer readings of typical factory process streams.

Table 4c. Refractometer brix: refractometer vs hydrometer for typical factory process streams.

Sample	Average of 8 readings		Standard deviation	
	Refractometer	Laboratory hydrometer	Refractometer	Laboratory hydrometer
Mixed juice	17.21	17.07	0.1335	0.0372
Syrup	59.62	60.00	0.0459	-
A Molasses*	39.88	39.91	0.0513	0.0273
B Molasses*	34.95	35.69	0.0418	0.0181
*Double dilution				

Table 4d is of particular interest since the juice samples contained an extremely high volume of suspended material. For the pilot plant samples, the solids were permitted to settle in the hydrometer cylinder. The factory samples were those procured from the cane wash water studies noted previously.

Table 4d. Refractometer brix: mixed juice with high suspended solids.

Parameter	Pilot plant no.			
	1		2	
	Refractometer	Hydrometer	Refractometer	Hydrometer
Initial reading	13.54	14.35	12.12	14.01
Constant reading	-	13.84	-	12.37
Time, minutes	-	45		155
	Factory*			
	A		B	
	Refractometer	Hydrometer	Refractometer	Hydrometer
Crusher juice	12.48	12.53	13.55	13.50
Mixed juice	11.98	12.00	11.85	11.86
*Refractometer sample from clear juice at top of hydrometer cylinder. Hydrometer sample from settled and decanted juice.				

In this case, the hydrometer samples were allowed to settle in a large container, after which the settled liquid was decanted into the hydrometer cylinder. All refractometer samples were procured by means of a medicine dropper which was inserted into the hydrometer cylinder--above the settling material and just under the scum level. As a matter of interest, the recommended practice in Hawaii is to prepare the refractometer sample by filtering through filter aid and filter paper.

For one Audubon Sugar Factory pilot plant sample, 45 min were required for the hydrometer reading to reach consistency--and 155 min for the other sample. In all cases, good agreement was observed between the refractometer reading and the hydrometer reading of the settled sample.

One objective of these studies is to encourage some of the factories to procure the newer refractometers and to conduct their own observations, since obviously the industry must have a meeting of the mind before any changes are contemplated in the method of determining brix.

MUD FILTRATION

Mud filtration problems were another byproduct of the high volume of field soil entering the factories during the 1971 crop. Proper filter operating conditions became a major factor in attempting to keep up with the mill, and lost time or reduced grinding rates a/c clarifier and/or mud filter limitations were a common entry on the daily operating reports. Since the fabric covered filter has been increasingly accepted by the industry, laboratory studies were conducted in 1970 and 1971 on a 0.1 ft² leaf-type filter covered with the commercial polypropylene cloth. The following parameters were investigated: temperature, bagacillo, pH, and coagulant.

From Table 5a (effect of temperature) it is evident that high filtration rates are associated with elevated temperatures. These data suggest the possibility of adding heating elements to the mud-bagacillo mixing tank--or to the mud tank preceeding the bagacillo mixing trough.

Table 5a. Mud filtration: effect of temperature.

Parameter	Year	
	1970	1971
Dry solids, % on mud	20.5	-
Bagacillo, % on mud	3.0	-
pH	6.8	-
Coagulent, ppm on mud	103	-
Vacuum, in. mercury	10	-
Temperature °F	gal/ft ² -min	
100	0	
150	1.216	
170	2.907	
180	3.435	
190	4.017	
200	4.651	

Table 5b. Mud filtration: effect of bagacillo.

Parameter	Year	
	1970	1971
Dry solids, % on mud	20.5	35.8
Temperature, °F	190	190
pH	6.8	7.5
Coagulent, ppm on mud	103	150
Vacuum, in. mercury	10	12
Bagacillo, % on mud	Gals/ft ² - 30 sec.	
0.8	2.748	
1.5	2.850	
3.0	3.911	
4.4	4.598	
-	-	
Bagacillo, % on mud	Gals/ft ² - min.	Light transmission
1.0	2.220	39
-		
3.0	2.273	25
-		
5.0	2.643	24

From Table 5b, it is evident that the amount of bagacillo is most critical with dilute muds. The 1970 studies with only 20.5% dry solids on muds show a 42% increase in filtration rate for an increase from 0.8 - 3.0% bagacillo on muds. To the contrary, the 1971 studies, with a denser mud samples of 35.8% dry solids, show only a minimal increase in filtration rate for the same increase in bagacillo. Since the continuous-belt type filter can be operated without bagacillo, but at a markedly reduced rate, it is unfortunate that there are no data for 0% bagacillo on mud.

Table 5c (effect of pH) indicates the optimum mud pH to be about 7.0.

Table 5c. Mud filtration: effect of pH.

Parameter	Year	
	1970	1971
Dry solids, % on mud	20.5	35.8
Temperature, °F	190	190
Bagacillo, % on mud	3.0	3.0
Coagulent, ppm on mud	103	150
Vacuum, in. mercury	10	12

pH	Gals/ft ² - min.
6.2	1.955
6.8	4.492
7.1	4.439
7.8	4.069
8.6	3.964
9.5	3.700

pH	Gals/ft ² - min.	Light transmission
6.5	1.903	21
-	-	-
7.0	2.325	19
7.5	2.273	25
8.0	2.907	34

Under normal crop conditions with reasonably clean cane and good mud consistency, pH at the mud filter station is generally no problem, and lime is rarely added to the muds. Under adverse conditions, the need to add lime to maintain pH is evident--assuming that the mud pH is about that of the clarified juice, i.e., 6.2 - 6.5. Low density lime may pose a problem with dilute muds. While a 3 - 5° Be lime solution may be ideal for automatic juice liming, a more dense material of 8 - 10° Be may be necessary for the muds to minimize dilution.

The need for a coagulent in mud filtration is generally recognized, and the data in Table 5d show the expected trend in filtration rate as a function of coagulent dosage. Here Separan AP-30 was used.

Table 5d. Mud filtration: effect of coagulent* - 1970.

Parameter	Value
Dry solids, % on mud	20.5
Temperature, °F	190
Bagacillo, % on mud	3.0
pH	6.7
Vacuum, in. mercury	10

Coagulent ppm on mud	gals/ft ² - 30 sec.
18.9	1.480
37.0	1.691
71.5	3.118
103.4	3.911
148.0	4.757 plus

*Separan AP-30

Data need to be compiled on the type of coagulent which is most effective. Separan AP-30 is a cationic polyacrylamide-type coagulent. Comparable results have been observed with other cationic polyacrylamide-type additives which are commercially available. This type of additive is most effective in an alkaline medium. It is possible that an anionic or nonionic additive would be more effective for mud filtration.

As these data might reflect filter design parameters, it is noted that the filtration rates recorded are pretty well above those encountered in industry.

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HIGHER SUGARCANE YIELDS THROUGH HIGHER POPULATIONS

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INTRODUCTION

High plant populations (stands) are essential to good yields. With sugarcane the initial stand is especially important because it affects yields for several years. Maximum stands are seldom obtained in Louisiana. Many cultural practices have improved stands and increased yields. These include land preparation to improve drainage, precision grading and pre-planting cultivations, agronomic practices including planting dates, planting rates, and planting depth (1, 3, 4, 7, 8). Substantial increases in plant populations and yields have been made on some farms.

Recent studies show that stalk population, as well as stalk length, weight, and diameter, are associated with yields. Legendre (6) found a close association between stalk population, length, and weight; stalk diameter was not as significant as a contributor to yield. R. D. Breaux (unpublished) obtained similar results from another study; the association between stalk population and yield was very close in both plant and stubble cane.

Populations near 30,000 mature stalks per acre seem to be the maximum under present practices. The assumption that more seedpieces placed in the ground would increase yields is not well founded. Heavier planting rates often give higher early stands, but competition eliminates most of the added shoots during the growing season. Experiments with increased planting rates on conventional rows have given either slight increases or no significant increases in yield (unpublished data).

If more stalks cannot easily be obtained on a conventional row, perhaps populations could be improved if the rows were spaced more closely. Row spacing experiments with sugarcane have been conducted by several investigators (2, 5, 9, 10). The present Louisiana system is based on a row 6 feet wide. This system permits sunlight to fall on bare ground rather than sugarcane plants for about 75% of our short growing season.

Higher yield potential of modern varieties, high fertilization rates, improved drainage and pest control have allowed many Louisiana farmers to triple the average sugarcane yield over that obtained by their fathers or grandfathers. Further yield increases may be obtained by improved cultural practices and new varieties but a significant increase may also be obtained by simply planting 2 rows of cane where one grew before. This paper reports on research that investigated the effects of row widths and rates of planting on 6-foot rows, on yields.

EXPERIMENTAL PROCEDURE

Four experiments were conducted on a Mhoon silt loam to determine the effect of higher populations on yields. All experiments utilized 150 lb of ammonium nitrate per acre. Experiment A, started in 1970, was a rate of planting experiment utilizing a 2 x 2 x 3 factorial design and 4 replications. All rows were 72 in. apart on a single drill. Two varieties, CP 61-37 (normally with adequate populations) and L 62-96 (normally with low populations) were used. There were 2 "seed" cutting methods: machine cut and hand cut. Planting rates were: 2 stalks plus 10% lap, 3 stalks plus 10% lap, and 4 stalks plus 10% lap.

Experiment B, also started in 1970, was planted in a simple randomized block design with 4 replications. There were 3 treatments: 36-in. rows, single drill; 72-in. rows, single drill; and 72-in. rows, double drill 15 in. apart. The variety was CP 52-68 using 2 stalks plus a 10% lap for each drill.

Experiment C, beginning in 1967, was planted using a split-split plot design. Three row widths were used as the main plots: 36, 42, and 72 in. in width. Main plots were divided into sub-plots using 2 varieties: CP 61-37 (high vigor-average sucrose) and CP 48-103 (low vigor-high sucrose). Sub-plots were divided using 2 planting rates: 1-1/2 stalks plus a 10% lap (below standard rate), and 2 stalks plus a 10% lap (standard rate). Treatments had 5 replications. Plant cane, first stubble, and second stubble data were obtained.

Experiment D, started in 1969, was planted to the same design and row widths as Experiment C. Variety CP 61-37 was used again but L 60-25 (average vigor-high sucrose) was substituted for CP 48-103. Planting rates were: 2 stalks plus a 10% lap and the standard rate of 2 stalks plus a 10% lap. Treatments had 4 replications. Plant cane and first stubble data were obtained.

Data obtained (September) included mature stalk population counts, stalk height, stalk size, and stalk weight. Experiments were harvested during the normal harvesting period for the plant cane and stubble crops. Plots were weighed to determine cane per acre yields, and samples were obtained for juice analysis to determine sugar-per-ton and sugar-per-acre yields.

RESULTS

In experiment A, "seed" cut by hand yielded 5.17 tons per acre more than "seed" cut by machine (Table 1). Planting rates of 3 stalks and 4 stalks on 72 in. rows resulted in no significant increases in yields of cane per acre compared with 2 stalks (standard rate).

Table 1. Yields of cane in tons per acre for plant cane using 2 varieties, 2 methods of cutting seed, and 3 planting rates (Experiment A).

Planting rate	Variety							
	L 62-96				CP 61-37			
	Hand cut	Machine cut	Mean		Hand cut	Machine cut	Mean	
2 stalks	32.78	29.79	31.28	::	38.98	30.92	34.95	
3 stalks	34.32	30.78	32.55	::	35.98	31.45	33.71	
4 stalks	35.25	26.85	31.05	::	35.12	31.58	33.35	
Mean	34.12	29.14	31.63	::	36.69	31.32	34.00	

LSD .05: Differences between planting rates as an average of 2 methods of cutting not significant.
Differences between method of cutting as an average of 3 planting rates = 2.84 tons.

Experiment B showed highly significant increases of mature stalk populations and yields of 36-in. rows over 72-in. rows (Tables 2 and 3). Two drills on 72-in. rows, however, resulted in a significant increase of population over the standard 72-in. rows but yield was not significantly increased. Sucrose content was not affected by the different treatments.

Table 2. Plant populations (mature stalks) per acre for plant cane of CP 52-68 using 3 row types (Experiment B).

Row type	Populations
36" - 1 drill	40,890
72" - 2 drills	33,930
72" - 1 drill	20,807
LSD .05	1,732

Table 3. Yields of cane in tons per acre for plant cane of CP 52-68 using 3 row types (Experiment B).

Row type	Yield
36" - 1 drill	47.86
72" - 2 drills	36.85
72" - 1 drill	33.38
LSD .05	5.19

In experiment C, plant populations (mature stalk counts) from each rate of planting also increased considerably on reduced row widths (Table 4). Rows 36-in. apart had slightly higher populations than the 42-in. rows, and much higher than the 72-in. rows. The standard planting rate significantly increased populations over the lower planting rate. Stalks weighed slightly less and were shorter in the narrow rows (data not shown). Stalk diameter measurements were too variable to be conclusive (data not shown). Stalk diameter, stalk height or stalk weight were not significantly correlated with yield in the experiment.

Table 4. Plant populations (mature stalk count) per acre as influenced by row width x variety x rate during 1968-70 (Experiment C).

Row width and crop	Variety							
	CP 48-103				CP 61-37			
	Below	Standard	Standard	Mean	Below	Standard	Standard	Mean
	rate ^{1/}	rate ^{2/}	rate ^{2/}	Mean	rate	rate	rate	Mean
Plant cane								
36"	30,908	34,468	32,688	32,688	36,284	45,022	40,653	40,653
42"	27,190	32,883	30,036	30,036	34,709	40,514	37,611	37,611
72"	20,167	22,683	21,425	21,425	24,900	26,946	25,923	25,923
Mean	26,088	30,011	28,050	28,050	31,964	37,494	34,729	34,729
First stubble								
36"	39,978	40,995	40,486	40,486	45,883	47,335	46,609	46,609
42"	36,798	38,831	37,814	37,814	40,739	42,267	41,503	41,503
72"	24,273	25,555	24,914	24,914	28,653	27,806	28,229	28,229
Mean	33,683	35,127	34,405	34,405	38,425	39,136	38,780	38,780
Second stubble								
36"	29,178	32,088	30,633	30,633	43,262	42,059	42,660	42,660
42"	25,630	31,072	28,351	28,351	36,254	36,918	36,586	36,586
72"	24,336	26,484	25,410	25,410	28,808	29,717	29,262	29,262
Mean	26,381	29,881	28,131	28,131	36,108	36,231	36,169	36,169
3 crops								
36"	33,355	35,850	34,602	34,602	41,810	44,805	43,307	43,307
42"	29,873	34,262	32,067	32,067	37,234	39,900	38,567	38,567
72"	22,924	24,907	23,915	23,915	27,454	28,156	27,805	27,805
Mean	28,717	31,673	30,195	30,195	35,499	37,620	36,560	36,560

^{1/} 1-1/2 stalks plus 10% lap.

^{2/} 2 stalks plus 10% lap.

LSD .05: Differences between row widths as an average of 2 planting rates for 3 crops = 3,376 stalks.
Differences between planting rates as an average of 3 row widths for 3 crops = 1,836 stalks.

Yields of cane per acre on narrow rows increased significantly over the 72-in. rows (Table 5). The yields of 36-in. and 42-in. rows were not significantly different but each yielded significantly more than the 72-in. rows. In plant cane, CP 61-37 yielded 50.65 tons using the standard rate of planting on 36-in. rows compared to 32.47 tons on 72-in. rows. Large differences were also obtained with CP 48-103.

Table 5. Yields of cane in tons per acre for plant cane, first and second stubble crops (row width x variety x rate during 1968-70) (Experiment C).

Row width and crop	Variety							
	CP 48-103				CP 61-37			
	Below	Standard	Standard	Mean	Below	Standard	Standard	Mean
	rate ^{1/}	rate ^{2/}	rate ^{2/}	Mean	rate	rate	rate	Mean
Plant cane								
36"	30.29	34.64	32.46	32.46	40.82	50.65	45.73	45.73
42"	27.19	33.87	30.53	30.53	38.70	44.16	41.43	41.43
72"	20.57	23.25	21.91	21.91	28.51	32.47	30.49	30.49
Mean	26.02	30.59	28.30	28.30	36.01	42.43	39.22	39.22
First stubble								
36"	35.09	32.60	33.84	33.84	39.86	43.71	41.78	41.78
42"	33.31	33.73	33.53	33.53	36.87	35.94	36.40	36.40
72"	26.96	26.16	26.56	26.56	28.82	28.22	28.52	28.52
Mean	31.79	30.83	31.31	31.31	35.18	35.96	35.57	35.57
Second stubble								
36"	25.80	26.21	26.00	26.00	44.33	43.70	44.01	44.01
42"	25.78	29.86	27.82	27.82	40.46	40.67	40.56	40.56
72"	24.44	28.02	26.23	26.23	36.04	36.11	36.07	36.07
Mean	25.34	28.03	26.68	26.68	40.28	40.16	40.21	40.21
3 crops								
36"	30.39	31.15	30.77	30.77	41.67	46.02	43.84	43.84
42"	28.76	32.49	30.62	30.62	38.68	40.26	39.47	39.47
72"	23.99	25.81	24.90	24.90	31.12	32.27	31.69	31.69
Mean	27.71	29.82	28.76	28.76	37.16	39.52	38.34	38.34

^{1/} 1-1/2 stalks plus 10% lap.

^{2/} 2 stalks plus 10% lap.

LSD .05: Differences between row widths as an average of 2 planting rates for 3 crops = 4.08 tons.
Differences between planting rates as an average of 3 row widths for 3 crops = 1.67 tons.

Yields from the 2 planting rates differed significantly; the standard planting rate yielded more than the lower planting rate.

There was a significant interaction of row widths and varieties. CP 61-37 responded better to the narrow rows than CP 48-103 for the 3 crop average.

In experiment D, the narrow rows also significantly increased plant populations (Table 6). Large and significant differences in yield of cane per acre were again obtained with narrow rows compared to the standard row width (Table 7). L 60-25 averaged 42.00 tons and 41.63 tons for the 36- and 42-in. rows compared to 29.57 tons for the 72-in. rows (2 crops). CP 61-37 averaged 46.36 and 48.08 tons for the 36-in. and 42-in. rows compared to 32.30 tons for the 72-in. rows (2 crops). Some 36-in. rows were damaged with heavy equipment causing slightly lower yields than for the 42-in. rows in a few plots (first stubble crop).

There were no significant differences in sugar per ton of cane on the differing row widths or different planting rates for all experiments (data not shown).

Table 6. Plant populations (mature stalk count) per acre for plant cane as influenced by row width x variety x rate during 1970 (Experiment D).

Row width	Variety							
	L 60-25				CP 61-37			
	Standard		Above		Standard		Above	
	rate ^{1/}	rate ^{2/}	standard	rate ^{2/}	rate	standard	rate	Mean
36"	33,756	37,878	35,817		37,102	36,326	36,714	
42"	30,004	30,121	30,062		31,000	32,287	31,643	
72"	18,731	21,344	20,037		22,457	23,353	22,905	
Mean	27,497	29,781	28,639		30,186	30,655	30,421	

1/ 2 stalks plus 10% lap.

2/ 3 stalks plus 10% lap.

LSD .05: Differences between row widths as an average of 2 planting rates = 3,495 stalks.
Differences between planting rates as an average of 3 row widths = N.S.

Table 7. Yields of cane in tons per acre for plant cane and first stubble crops (row width x variety x rate during 1970-71) (Experiment D).

Row width and crop	Variety							
	L 60-25				CP 61-37			
	Standard		Above		Standard		Above	
	rate ^{1/}	rate ^{2/}	standard	rate ^{2/}	rate	standard	rate	Mean
Plant cane								
36"	38.99	43.56	41.27		46.01	41.77	43.89	
42"	34.95	38.55	36.75		36.11	41.33	38.72	
72"	24.82	28.60	26.71		28.41	29.89	29.15	
Mean	32.92	36.90	34.91		36.84	37.66	37.25	
First stubble								
36"	37.92	47.55	42.73		48.99	48.67	48.83	
42"	50.55	42.48	46.51		61.08	53.82	57.45	
72"	30.69	34.19	32.44		34.98	35.96	35.47	
Mean	39.72	41.41	40.56		48.35	46.15	47.25	
2 crops								
36"	38.45	45.55	42.00		47.50	45.22	46.36	
42"	42.75	40.51	41.63		48.59	47.57	48.08	
72"	27.75	31.39	29.57		31.69	32.92	32.30	
Mean	36.32	39.15	37.73		42.59	41.90	42.25	

1/ 2 stalks plus 10% lap.

2/ 3 stalks plus 10% lap.

LSD .05: Differences between row width as an average of 2 planting rates for 2 crops = 6.35 tons.
Differences between planting rates as an average of 3 row widths for 2 crops = N.S.

DISCUSSION

Sugarcane population and yield increases were attempted through increased planting rates on standard 72-in. rows, 2 drill on 72-in. rows, and closer row spacing. Heavier planting rates on 6-ft rows resulted in larger spring populations (data not shown) but did not increase yields. Competition between plants on the same row reduced the final stalk population to about 30,000 per acre, which was usually obtained with the normal planting rate.

Using 2 drills on a 6-ft row increased and maintained a larger population, but the yield increase compared to 6-ft single drill rows was not significant. The increased stalk population was accompanied by a corresponding decrease in stalk weight. Further testing will be required to determine the consistency of this result and the reasons for the accompanying reduction in stalk weight.

However, population increases through decreased row width increased yields. In these experiments, involving 6 crop-years, there were consistent, large yield increases on row widths closer than the 6-ft standard. Increases of up to 15 - 20 tons per acre were obtained with 3 3-1/2 ft rows.

Louisiana has a much shorter growing season than tropical cane producing areas; consequently, there is an incomplete crop cover and relatively inefficient light utilization for a greater proportion of the total growing season. Larger positive yield responses to narrow rows might be experienced under Louisiana conditions. Narrow rows should be considered as a means of increasing yields in Louisiana.

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FARM SAFETY

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(This paper was not available for printing in the Proceedings).

HOT-WATER TREATMENT FOR MOSAIC AND RATOON STUNTING DISEASE CONTROL

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ABSTRACT

This paper describes a method for heat-curing virus diseases that uses a series of treatments; a treatment at lower temperature precedes one or more treatments at higher temperature, and each treatment is separated from the one that follows by an interval of a day. With certain combinations of treatments, it is possible to free the majority of setts of CP 44-101 from symptoms of the sugarcane mosaic and RSD. It has not been possible so far to free all the treated setts from both. The method depends on the ability of the damaged plant to repair itself and to adapt to heat. It remains to be established whether sugarcane viruses within the plant also can adapt to heat like some other viruses (23, 10). With favorable combinations of treatments, there has been little loss in germination. It should be noted that the experiments have been done with relatively mature canes harvested from October to December. Use of repeated treatments instead of a single treatment allows for a wider choice of combinations, not only of the number of treatments, but also of the length and temperature of each. In the experiments described, the duration of each treatment in a series has been held constant. Major factors which may influence the outcome of the heat treatment, besides the combination of heat treatments applied, include the vigor of the plants to be treated, the environmental conditions between and after heat treatments, the rate of heat transfer within the cane, and the kind and strain of virus.

HEAT TREATMENT FOR THE CONTROL OF DISEASE

The body temperature of an adult human being is nearly constant unless an infection occurs: then the body usually responds with a rise in temperature. What does the fever do? It tends to slow the growth and multiplication of the disease-causing organism and to increase the activity of the body's various defenses. After the infection subsides, the body, during a period of convalescence, repairs the damage caused by the disease and by the fever.

Unlike man, plants do not maintain a constant body temperature, nor do they have systemic defense reactions. The body temperature of a plant is usually rather close to the outside temperature. On a cold day, the plant is cold; when it becomes warmer, the plant becomes warmer. In the plant, the defenses against infection are cellular; in man, the defenses are cellular and also circulative, for blood can carry antibodies and white blood cells throughout the body. To use a military analogy, the fighting between the plant and the disease-causing organism is house-to-house, every cell for itself, whereas in man, besides this localized fighting, there is a massive mobilization and movement of troops to give battle and to search out pockets of resistance.

Because the plant has no constant body temperature, it is very easy to raise the temperature to any desired level by exposing the plant to heated air or by immersing it in hot water. Furthermore, it is possible, if not always practical, to heat the whole plant or any part of it, as desired. A plant might be cured by heat provided a temperature and a time of treatment are found that favor the sick plant over the disease-causing organism. This expectation has often been met (16). A multitude of crop plants in the form of seeds, setts, bulbs, corms, runners, and whole plants has been heat-treated for their many afflictions, and the surviving plants have been freed from numerous kinds of molds, bacteria, mycoplasmas, viruses, nematodes, insects, and mites. Just the viral and mycoplasmal diseases that have been cured in this way number well over a hundred (14).

Within a year of the first description of the control of a plant disease by heat (smut on cereal grains), Sayer and Kobus, in 1888 and 1889, respectively, experimented with hot-water treatment of setts of sugarcane for the control of sereh; a successful treatment was achieved 35 years later (21). Since then, numerous other sugarcane diseases have been controlled by heat, including smut (19), downy mildew (20), leaf scald (18), white leaf (12), grassy shoot (24), mosaic (5), chlorotic streak (13), and ratoon stunting disease (RSD) (17). Chlorotic streak and ratoon stunting disease have been heat-cured on a commercial scale. A heat-treatment for the control of arthropods is regularly applied to interstate shipments from the World Collection of Sugarcane at Canal Point.

Thus, heat-treatment is an important tool for the control of all types of diseases; it is especially important for the control of virus diseases of vegetatively propagated plants like sugarcane. Chemical treatment for the control of virus diseases of plants are ineffective, as are treatments involving

irradiation. The gains in resistance to virus infection achieved through breeding are often offset by the loss of desirable varietal characteristics. Heat treatment, if it were to become as successful as I think it can, would eliminate the several diseases that a perennial plant is likely to gather in its cumulative lifetime. It would do for vegetatively propagated plants what seeds do for many sexually propagated ones: permit a return to a disease-free beginning.

Despite the success that has been achieved so far, heat treatment of sugarcane still falls far short of its potential. Attempts to control some sugarcane diseases, such as bacterial gumming disease (21) and red rot (15), have failed. Among the diseases which can be controlled, there are still problems. The low survival rate of heat-treated seed-cane has often been discouraging. The persistence of RSD among a small percentage of those heat-treated has been a source of continual reinfection in the seed plots. Furthermore, where the incidence of mosaic is high, treatment for RSD alone has seemed, however mistakenly, to be futile. It seems appropriate, therefore, to reexamine those factors involved in heat treatment which may increase its effectiveness.

VIRAL INACTIVATION AND HEAT CURES

To simplify the discussion, I shall only consider treatment with hot water. Hot-air treatment permits the higher survival of young cane stalks, but is accompanied by several technical difficulties. One is to achieve a constant temperature and an even flow of air throughout the oven; a second is to evaluate the effect of the evaporation of water from the stalk surface in lessening the temperature gradient from outside air temperature to inside plant temperature. A third is the low heat capacity of air which requires time-consuming treatments.

In a heat-treatment like that for RSD, the temperature and time required are near the lethal level of the cane. As for the virus, so for the host: The longer the treatment, or the higher the temperature, the greater is the mortality. Practically, this often means that as the severity of the treatment increases, more of the survivors are cured, but there are fewer survivors (7). In my opinion, this Hobson's choice, this impasse between choosing cure or survival, is the single most important factor limiting the application of heat treatment to sugarcane diseases.

What does a cure signify? For the sugarcane plant, it means that the shoot arising from the treated sett and all the shoots from that shoot are free of virus in so far as can be determined; it also means that the shoot and its progeny can be deliberately reinfected by the same virus to give rise to the same pattern of disease and can again be cured. For the virus in the diseased plant, a cure would indicate that it has been barred from showing its infective capabilities in the new growth either by being confined or by being completely inactivated. It is not yet possible to distinguish between these alternatives.

Virus can be confined in the heat-treated plant by blocking viral synthesis or viral transport from cell to cell. The cellular machinery needed for viral synthesis may be damaged by heat so that the plant would be temporarily immune; virus particles transported to such resistant cells may be harmless to the plant for, if virus particles in a newly invaded cell cannot initiate infection soon after their entry, they may lose the capability to do so (3). Alternatively, virus particles may become confined by being trapped in the heat-damaged cell through the obstruction or destruction of cell-to-cell pathways of transport, or through being caught in clumps of coagulated protoplasm. The kinds of cellular damage which would interfere with infection would interfere with the normal growth of the plant, but the plant may have more time for repair than the virus can functionally afford.

The virus already present in the cell may be completely inactivated either as a direct effect of heat or by virus degradation by the enzymes of the plant. A certain amount of virus degradation seems to occur with a number of virus diseases, and certain heat treatments are thought to activate this degradation. The role of enzymes in sugarcane virus degradation has not been established.

How does heat inactivate virus? To study viral inactivation, the virus must be extracted from the plant. Increased heat apparently causes a loosening of the bonds both in the nucleic acid and protein of which virus is constituted (9). In the nucleic acid this may lead to a break in the linear arrangement of nucleotides and the consequent loss of infectivity. In proteins, bonds holding the chain of amino acids together may be broken, or, more likely, the architecture of the folding of the chain may be destroyed. One consequence of the random unfolding of the chain is to denature the protein, to make it less soluble in water, and consequently, to lead to coagulation. The still infectious nucleic acid may then be trapped within the denatured protein shell. Whether nucleic acid breakage or protein denaturation is responsible for its inactivation depends on the kind of virus.

The rate at which viruses, like the proteins or nucleic acids of the plant, are inactivated is determined by the temperature. The higher the temperature, the faster the inactivation. At constant temperature, there is an exponential drop in concentration with time. Different viruses are inactivated at different temperatures, and for a long time the thermal inactivation point has been used as a characteristic of viruses. The thermal inactivation point is defined as the lowest temperature at which the infectivity of the virus in the juice of its host plant is inactivated in 10 min. Thus, no infectivity remained for strain H of sugarcane mosaic at 51 C, and for strain A at 53 C (1). The thermal inactivation point for the virus of RSD does not seem to have been determined.

How does inactivation of virus in the test tube differ from a heat cure in the plant? Numerous points have been discussed (9, 11, 22), and several of these may be mentioned: 1) Virus particles in a test tube have to be inoculated into a living plant to test for infectivity, and the inoculation techniques with plant viruses are generally insensitive. Thus, even though 50,000 virus particles may not cause a single infection in an inoculation experiment, a single virus particle in the right place in the plant may start the infection. In a diseased plant that has been heat treated, the single surviving virus particle could well be in the right place.

2) The rate of inactivation of purified virus is very much influenced by pH, by the salts present, and by their relative concentration. The conditions within the cell are not known nor are they known to be uniform, and the rates may be very different from those determined in the test tube.

3) The virus in the plant is likely to be present both in its nucleoprotein and its free nucleic acid form. Both forms are infectious, but the rates of inactivation may well be different, especially if the virus in the test tube is inactivated through protein denaturation.

4) Virus inactivation data are based on the decrease in concentration of virus, not on its total elimination. Present information suggests that the last virus particle may not be as readily destroyed as the first.

5) The time required for the transfer of heat within the treated plant until all parts and all virus particles have reached the outside water temperature may be quite variable. For sugarcane, the factors which contribute to the time required to reach temperature equilibrium include both the length and diameter of the sett, the heterogeneity in structure, and hence in conductivity, of the stalk, the insulating effect on the embryonic tissue of the leaves nesting within each other in the bud, and the efficiency of the treatment tank to ensure turbulent flow of water at constant temperature over all parts of the sett.

Direct inactivation, as it would be in a test tube (11), is one approach to the cure of an infected plant. This approach, even though it uses a relatively well understood mechanism, cannot predict precisely the minimum conditions required for a heat cure; furthermore, this approach does not attempt to discriminate between damage to virus and to plant.

SURVIVAL AND ADAPTATION TO HEAT

When an approach involving the plant is considered, the factors that govern the inactivation of virus in the test tube still apply. What is less well understood is how much of the cure is due to the inactivation of the virus by heat and how much is due to the role of the plant (11, 22).

The survival of a sugarcane sett is measured by the ability of the treated bud to give rise to a normal-growing plant. This means that enough cells must survive to carry on the coordinated function involved in organizing and supplying a developing shoot. Experience has shown that the response of setts even to the same treatment may be variable. Survival is related to the "state" of the plant from which the sett had been taken. For sugarcane, setts from vigorous, field-grown plants which are approaching maturity but which are not senescent seem to withstand heating best. The survival of setts may be increased by practices related to the care of the setts before and after heat-treatment (2); the storage of cut cane for a day or more before treatment seems to help the survival of relatively immature cane. Again, the disease itself may affect the resistance to heat damage of the host (23). Lastly, varieties differ in their ability to withstand the stress of heat treatment.

The steps which lead from exposure to heat to the death of cells and plant are thought to begin with denaturation of some cell proteins, followed by the destruction of membrane and organelle structures, and ending in the loss of vital functions (6).

It has been repeatedly shown in the last decade that plants or plant parts can increase their tolerance to heat, that is, become adapted; to demonstrate adaptation, a treatment at a high temperature is followed after an interval by treatment at a higher temperature (23). Such a combination of treatments was used by Wang (20) for the control of downy mildew in sugarcane, but seems otherwise not to have been used.

The results in Table 1 illustrate adaptation for sugarcane. The stalks for this experiment were from field-grown, presumably healthy, 1st stubble L 60-25. Setts, 6-cm long and having a single bud, were carefully selected. From each stalk, one sett was assigned to each treatment; there were 36 stalks which contributed 7 setts each to 7 treatments, and an additional 18 stalks which contributed 6 setts each to 6 treatments. One sett was misassigned from the double treatment at 57.3 C to the single treatment. The age of the setts (as determined by the original position on the stalk) was distributed arbitrarily among treatments. This method of distribution of setts among treatments is made necessary by the potential variability among stalks in their response to heat and has been applied in experiments in which sugarcane setts are heat-treated.

Table 1. The effect of combining 15-min. hot-water treatments at different temperatures on the survival of setts of field-grown sugarcane, L 60-25.

Day and temperature (°C) of treatment		No. treated	Survivors (%)
1st	2nd		
28	-	54	94
52	-	36	97
57.3	-	55	35
52 + 57.3	-	54	2
52	52	54	94
52	57.3	54	89
57.3	57.3	53	6

The setts, except when treated, were at a temperature near 26 C. Throughout the period of treatment and until planted, the setts were kept in moist cheesecloth. When planted, which in this as in most of these experiments was the day after treatment was completed, the setts were placed in sterilized vermiculite in 7.5-cm peat pots placed on soil. There were 24 pots to a flat, and the records were kept so that each sett could be followed. The flats were moved to a greenhouse. The plants were fertilized and fumigated weekly.

During the time of treatment, the temperature varied no more than 0.5 C and usually less than 0.2 C; the temperature was determined with standardized thermometers.

The results in Table 1 show that a single 15-min. treatment at 52 C has no adverse effect on germination compared to the control (28 C), but that a treatment at 57.3 C does. Two 15-min. treatments a day apart at 52, or at 52 and 57.3 C, have little or no effect on germination. Two 15-min. treatments at 52 and 57.3 C separated by less than 30 min., or both at 57.3 C separated by a day, lower germination drastically. It should be added that the well known effect of heat treatments on the rate of germination was evident in this experiment, though the data are not included in Table 1. The setts treated at 52, at 52 and 52, and at 52 and 57.3 C germinated more quickly than the control and than the other heat treatments.

Similar results have been obtained with other varieties and also when combinations of temperatures of 52 and 56 C were used.

The results of Table 1 suggest that the interval of a day permitted setts treated at 52 C to become somewhat adapted to heat so that the treatment at 57.3 C is less severe than it would otherwise be. If the 1st treatment (57.3 C) damages too severely, or the 2nd treatment follows too quickly (30 min.), the already injured cane is more liable to injury than it would otherwise be.

Preliminary experiments have suggested that sugarcane actively adapts to greater tolerance to heat. It was found (5) that survival was better if a) the interval between heat treatments is 1 - 2 days, and if b) the temperature to which the setts are exposed between heat treatments and after the last treatment is near 25 C. If sugarcane does adapt, it would follow that if the 1st treatment is at the higher temperature than the 2nd, there should be less germination than when the lower temperature precedes the higher. In previous experiments, I was unable to show that there was a difference (5). In hindsight, it appears that this failure may have been due to using 2 temperatures too close together, or treatment times that were too brief. When I did this experiment with mosaic-infected Co 331, with two 15-min. treatments a day apart, among the 16 setts treated first with 57.3 and then with 52 C, one germinated; among the 16 treated with 52 and then 57.3 C, 13 germinated.

The results of numerous experiments have shown that if the plant from which the setts are taken is not in good condition initially, a series of treatments appears to be just as lethal as a single treatment would be. Neither spindly and senescent greenhouse-grown cane nor heavily bored and lodged field-grown cane has been successfully heat treated.

ADAPTED SUGARCANE AND HEAT CURES

At the Contact Committee Meeting last summer, I reported on the hot-water cure of plants infected with RSD by using 2 treatments, 30 min. each, at 52 and 54 C a day apart. Among the plants used were 2 varieties of *Saccharum spontaneum*, Coimbatore and US 4617, which after heat treatment were grown as uprights (4), and the sugarcane variety CP 45-184, which was planted conventionally. Only diseased setts were used for the heat treatment. After 5 - 6 months of growth in the greenhouse, the non-treated plants of the 3 varieties had excellent mature symptoms; CP 45-184 also had useful juvenile symptoms. The results of this experiment, presented in Table 2, show that with this treatment most, but not all setts are cured.

Table 2. Hot-water treatment for 30 min. each at 52 and 54 C a day apart and the cure of RSD.

Variety	Treatment	No. treated	Survivors (%)		Number with symptoms		Survivors symptom-free (%)
				+	-	?	
Coimbatore	HWT	178	99	1	174	2	98
	Control	56	98	54	0	1	0
U.S. 4617	HWT	199	75	0	149	1	99
	Control	53	89	44	0	3	0
CP 45-184	HWT	52	62	1	30	1	94
	Control	51	82	42	0	0	0

In experiments which I described this past November at the 14th Congress of ISSCT, I was able to show that 7-min. treatments at daily intervals of 54.8, 57.3, 57.3, and 57.3 C could cure some, though not all, cuttings infected with strains A, B, or D of the sugarcane mosaic virus. Treatments of 10-1/2 min. at 54.8 C repeated once or twice were sufficient to cure some cuttings infected with strains H or I (5).

The cures obtained with these 2 diseases and the good germination with field-grown cane (Table 1) suggested applying serial treatments to cane infected both with mosaic and RSD. Table 3 shows the results from one experiment with setts of doubly infected sugarcane of variety CP 44-101. The cane had become field-infected with an undetermined strain of sugarcane mosaic virus, but it had been inoculated with the RSD virus when planted in the field 2 years earlier. Except for the controls, which were dipped twice into tap water at room temperature (26 C) for 20 min., all setts were heat treated twice, on the 1st day in water at 52, on the 2nd at 57.3 C. Treatment duration ranged from 15 min. each to 25 min. Mosaic symptoms were identified on the basis of leaf mottling, RSD symptoms on the basis of juvenile symptoms (8), a pink discoloration of the young stalk below the apical meristem. The results of Table 3 indicate that both in terms of the number of plants germinated and the number of plants without symptoms of either disease, the treatment for 20 min. appears to be the most favorable. The results also suggested that cures for the two diseases occur independently as in this case none of the shoots from heat-treated setts had symptoms of more than one disease.

Table 3. The length of treatment (at 52 and 57.3 C a day apart) and the survival and number of shoots with symptoms developing from treated setts of sugarcane, CP 44-101, infected with both sugarcane mosaic and RSD viruses.

Length of each treatment (min.)	Survivors (%)	Disease	No. with symptoms			Survivors symptom-free (%)
			+	-	?	
0	84	Mosaic	66	0	1	0
		RSD	65	0	2	0
15	80	Mosaic	11	51	2	80
		RSD	3	52	9	81
20	82	Mosaic	2	63	1	95
		RSD	1	62	3	94
25	41	Mosaic	1	34	6	83
		RSD	0	27	14	66

A 2nd experiment with CP 44-101 from the same source examined the effect of different combinations of 2 temperatures on the germination and cure of a double infection. Three groups of 20 stalks were used for a total of 17 treatments. The control treatment and single 15-min. treatment at 52 C were repeated with each group. As the results for all groups indicated good germination and uniform infection, the results from the 3 groups of cane are presented together in Table 4. Symptoms were read as in Table 3. The column under symptoms designated with a question mark includes shoots too small to read as well as those with doubtful symptoms. The results in Table 4 show a decline in germination with single treatments at temperatures above 52 C. Some cures were effected by single treatments; plants free of juvenile symptoms of RSD followed treatments at 52 C or higher, and of mosaic at 58 C.

Table 4. The effect of 15-min. heat treatments on the survival and number of shoots with symptoms developing from treated setts of sugarcane, CP 44-101, infected with both sugarcane mosaic and RSD viruses.

Day and temperature (°C) of treatment		Survivors (%)	Disease	No. with symptoms			Survivors symptom-free (%)
1st	2nd			+	-	?	
26	-	89	Mosaic	53	0	0	0
			RSD	53	0	0	0
52	-	99	Mosaic	59	0	0	0
			RSD	58	1	0	2
54.8	-	75	Mosaic	30	0	0	0
			RSD	12	12	6	40
58	-	25	Mosaic	2	3	0	60
			RSD	0	5	0	100
49.2	57.3	92	Mosaic	18	16	3	43
			RSD	5	30	2	81
52	57.3	95	Mosaic	5	14	0	74
			RSD	1	17	1	89
54.8	57.3	90	Mosaic	5	9	4	50
			RSD	1	15	2	83
49.2	58	95	Mosaic	4	15	0	79
			RSD	5	9	5	47
52	58	90	Mosaic	2	16	0	89
			RSD	1	14	3	78
54.8	58	80	Mosaic	1	14	1	88
			RSD	0	14	2	88
52	59	80	Mosaic	0	14	2	88
			RSD	1	14	1	88

The germination following the 2 heat treatments does not show the marked decline with increase in temperature evident with the single treatment. The data suggest that a 1st temperature of 52 is more favorable than 49.2 C to increase the number of plants free of symptoms both of mosaic and of RSD. A further increase in the 1st temperature to 54.8 does not have this effect when combined with a 2nd temperature of 57.3 C. As a 2nd temperature, 58 or 59 C is more favorable than 57.3 C in reducing the number of plants with symptoms of mosaic. No combination of the 2 temperatures eliminated symptoms of both diseases entirely. As in the previous experiment, the plants are apparently freed of symptoms of mosaic and RSD independently; thus, among the plants from the 49.2 - 57.3 C treatment, 3/5 had mosaic symptoms, 1/7 had RSD symptoms, and as would be expected, 3 of 35 plants had both.

The results of Table 4 suggest that the optimum temperature for the 1st treatment is above 49.2 C. The effect of the 1st temperature was further examined in an experiment which had the 4 combinations of two 15-min. treatments a day apart of 46 or 52 with 57.3 or 58 C. The variety used was Co 331, which had become field-infected with an undetermined strain of sugarcane mosaic virus. The cane was 1st stubble, with a group of 28 stalks derived from cane planted after hot-air treatment, and a group of 31 stalks from cane planted after inoculation with the virus of RSD. Only symptoms of mosaic were read. Setts from source plants doubly infected appeared to survive much better when the 1st treatment temperature was 46 C than setts from source plants derived from the hot-air treated cane; however, the 2 sources were from plots in different parts of the field so that differences in growing conditions may have been present. The results of setts from both sources, added together in Table 5, clearly indicate that a 1st treatment temperature of 46 C, compared to 52 C, is not sufficient to protect the cane adequately from a 2nd treatment temperature of 58 C a day later. The lower survival of both control and treated setts probably results from a less adequate selection of setts due to the early browning of the prophyll in this variety. The germination for single 15-min. heat treatments at 46, 52, and 58 C was 82, 73, and 2%, respectively.

Table 5. The effect of 15-min. heat treatments on the survival and number of shoots with symptoms developing from treated setts of sugarcane, Co 331, infected with sugarcane mosaic virus.

Day and temperature (°C) of treatment		Survivors (%)	No. with mosaic symptoms			Survivors symptom-free (%)
1st	2nd		+	-	?	
-	21	69	39	0	2	0
46	57.3	62	22	13	1	36
46	58	31	4	14	0	78
52	57.3	81	36	12	0	25
52	58	75	21	21	2	48

The results presented have shown that the combination of 2 treatments of 15 min. each, a day apart, at 52 and 57.3 C has little or no adverse effect on the germination of setts. It seemed desirable to determine whether this relationship would hold if whole stalks were treated. For the treatment of whole stalks, an outdoor treatment tank has been used in which the water is circulated by a large pump, and heat is added as steam. The cane stalks to be treated, after all blades and sheaths have been removed, are suspended in the tank in a basket to permit the water to circulate freely around the cane and to protect it from direct contact with steam. With this arrangement and frequent additions of steam, the overall variation in temperature can be kept to less than a degree, and mostly within 0.3 C.

In one experiment, 60 stalks of mosaic-infected, field-run cane of each of 3 varieties were harvested, cleaned, and divided into 2 groups. One group was heat-treated twice for 15 min. at 52 and 57.3 C, a day apart. Both groups were planted on October 21, 1971, at the rate of 3 stalks to a 16 ft (4.9 m) plot. When the last stand count was taken, on January 15, there were, in 10 plots each of treated and untreated of CP 52-68, 85 and 43 shoots, respectively; of CP 65-357, 129 and 65 shoots, respectively; and for 9 plots each of CP 61-37, 86 and 62 shoots, respectively. For all 3 varieties, there were significantly more shoots from heat-treated stalks. On January 5, in the plots planted with heat-treated stalks, shoots with well-defined mosaic symptoms accounted for about half of all the shoots then germinated of CP 52-68 and CP 61-37, and for about a fifth of those of CP 65-357. As many of the shoots were too small to distinguish symptoms, these figures indicate that the heat treatment had not been effective in controlling mosaic.

In order to increase the level of control of mosaic and RSD, a 3rd treatment has been incorporated into recent experiments; whole stalks have been exposed to three 15-min. treatments of 52, 57.3 and 57.3 C on successive days. To measure the germination and disease control in stalks treated intact, all buds believed to be sound are marked with a wax pencil; then the stalks are assigned at random either to be heat-treated or to be controls. After the heat treatment has been completed, each stalk is divided into one-bud setts; only the setts with marked buds are planted and grown in the greenhouse. The shears used to cut the stalk are flame-sterilized after each sett is cut. Final results from these experiments are not yet available. Preliminary observations indicate that the germination is very good, but that mosaic control is not complete.

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A PATTERN FOR PROGRESS

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The invitation to appear before you indicated that I should discuss Louisiana State University's role in sugarcane, now and in the future. In dealing with this particular subject it is desirable, however, to get a better understanding of the history of the sugarcane industry itself, what it has meant to the State of Louisiana, and what has been its relationship to Louisiana State University. This early history of the sugarcane industry in Louisiana vividly illustrates the real pioneering roles that the Louisiana sugar industry and LSU have played in the development of the worldwide sugar industry. Also, the close cooperation between LSU and the sugar industry is a strong pattern that has always been evident. Observing the progress that has been made, two extremely important facts are noteworthy: one, the Louisiana sugar industry is made up of men who believe in banding together in cooperative efforts to solve the problems of their industry and they are willing to devote their own personal financial resources to this end; and two, LSU has always had and continues to have today a major commitment to agriculture and to serving the needs of the State of Louisiana in every way possible. This is part of LSU's total commitment to the development of the natural and human resources of the State of Louisiana. These two factors, the sugar industry's attitude toward attempting to solve its own problems and LSU's commitment to assisting the industry, have coupled together to establish a pattern of progress. In order to develop this thesis more fully consider the relatively small segment of history during the period between 1885 and 1927. This is a very brief period but it will serve to illustrate vividly this pattern of progress.

In 1885, Louisiana sugarcane growers were already banded together in a society called the Louisiana Scientific and Agricultural Society, and this Society established the Sugar Experiment Station. This Station was first located in Kenner, Louisiana, but in 1890 it was moved to larger quarters at Audubon Park in New Orleans where sugar growing and processing experiments were carried on for a number of years. The station was placed under the direction of W. C. Stubbs, and it was financed entirely by the sugarcane planters of Louisiana. A complete sugar house was erected on a scale large enough to give commercial results and altogether roughly \$100,000 worth of equipment was obtained, either by purchase or by gift. This Sugar Experiment Station is believed by many to be the first private research organization in the Western Hemisphere which was established by an industry to study its own problems. Its creation is a tribute to the sugar industry and to the type of men who comprise it. These men were willing to devote their own financial resources to a cooperative effort to improve their industry.

In 1887 the Louisiana Planter's Association was formed under the leadership of the distinguished Duncan F. Kenner, a prominent Louisiana sugarcane planter of the era. Also in 1887 the Hatch Act was passed by the Federal Congress, and in 1888 the Louisiana Legislature assented to the provisions of the Hatch Act. The sugar planters were instrumental in gaining this approval. Three Agricultural Experiment Stations were created by this: the North Station at Calhoun, the Baton Rouge Station, and the Sugar Experiment Station in New Orleans. These reported to the LSU Board of Supervisors through the Bureau of Agriculture.

In 1890 the Audubon Sugar School was started in New Orleans when W. C. Stubbs, Director of the Station, induced a group of sugarcane planters to equip and start the mill at the station. Several courses were offered and the Audubon Sugar School was operated on a tuition basis. For a description of the course the following quotation from an article by Charles E. Coates is interesting:

Up to that time, the cane sugar industry throughout the whole world had been carried on largely by rule of thumb. Few men scientifically trained in sugar chemistry were to be found outside of Europe. In 1890, therefore, at a meeting of the Louisiana Sugar Planters' Association, it was decided to establish, in connection with the Sugar Experiment Station, a school for the training of experts in sugar work. This was placed under the direction of Dr. Stubbs and was opened in 1891 as the Audubon Sugar School. So far as I know, this was the first, instance in America in which any industry established both laboratories for the scientific investigation of its problems and a school for the college training of men to put the theory into practice.

Post-Graduate Character of Work

As first outlined, the Audubon Sugar School was intended to appeal mainly to graduates of schools of engineering, and the course was distinctly post-graduate in character. The faculty was composed of some of the ablest men in the country, special stress being laid on research work. It soon became evident, however, that the number of college graduates who appreciated the opportunities in the sugar industry was quite small, and that the demand for training came mainly from men who had not received very much undergraduate training. Moreover, there were a number of applicants from tropical countries, whose preliminary studies had been of such a type as to make it impossible for them to take up, successfully, the advanced scientific work offered in the Sugar School. At the outset, therefore, the greater number of students were special students, very un-uniform in educational training, which, of course, handicapped the school materially. The course was two years in length, classes were held at the Experiment Station, and during the sugar season the students did the actual work in the fields, in the laboratory, and in the sugar house.

The school was successful from the outset and, in a couple of years, more students were applying for admission than could well be accommodated. In the meantime the Sugar Experiment Station was taken over by the State of Louisiana as part of the Louisiana State University, and the Planter's Association withdrew its financial support. With limited funds, the increasing demands upon its staff along purely research lines, and the growing magnitude of its routine work, the Station found it impossible to handle students also.¹

An alternate description of the demise of the Audubon Sugar School is given from another source:

"In 1895 and 1896 the price of sugar had dropped and interest in the courses lagged."²

In 1896 Col. Nicholson, then President of LSU, resigned and was succeeded by Col. Thomas D. Boyd. As one of his first acts Col. Boyd sent for Dr. Stubbs and discussed with him a plan for establishing a sugar school in connection with the College of Agriculture at LSU in Baton Rouge. As a result Col. Boyd presented to the LSU Board of Supervisors in 1896 a recommendation to create the Audubon Sugar School in Baton Rouge. This recommendation was adopted and the school was brought to Baton Rouge and placed under the direction of Charles E. Coates. (Dr. Coates came to LSU as a Professor of Chemistry in 1893, and he organized LSU's first football team in that year). It is desirable to understand something about the nature of LSU at the time the Audubon Sugar School was moved to Baton Rouge. The following quotation is taken from some of the early writings of Dr. Coates:

The amazing thing is that the university existed at all. It had almost no support from the state and had it not been for the self-sacrifice of Colonel David French Boyd, Colonel Nicholson, and subsequently of Colonel Thomas D. Boyd, it must have closed its doors. Salaries were barely sufficient for a meager existence. But such courses as were given were well given and the faculty itself was really strong, as I now look back at it.³

The Audubon School got off to a good start in Baton Rouge. The following quotation is from the Daily Reveille of May 15, 1897 in an article about the School: "With an enrollment of 60 students, the newly organized school opened in 1897."

A further quotation from Dr. Coates about the Audubon Sugar School and its early beginning in Baton Rouge is of interest:

"The Audubon Sugar School was organized at the beginning as a graduate course. Very few graduates of that day had had the undergraduate training necessary, so there had been very few students. I therefore wrote up a four year undergraduate course which was extended to five years in a short time. The first three years were purely scientific and strictly

¹ An Experiment in the Education of Chemical Engineers, Industrial and Engineering Chemistry (Vol. 9, No. 4, page 379, April 1917).

² Thomas D. Boyd-The Story of a Southern Educator, Louisiana State University Press, 1935, p. 165.

³ Charles E. Coates, "Recollections of Early Days."

non-technical. During the sugar season, the fourth and fifth year students went to the experiment station at Audubon Park, New Orleans, boarded at near-by homes, and ran the sugar house. They did all of the work--chemical, mechanical, and manual as well. They also had to assist with the agricultural experiments which were then being carried on. It soon developed that during the fourth and fifth years a number of graduate students from other schools took the work and were graduated from the Audubon Sugar School with B.S. degrees. It was considered undesirable to give the master's degree. It was the only school of its kind in the world, and eventually men were sent to it from all countries where sugar was grown--South Africa, Australia, Mauritius, India, Spain, Portugal, Italy, England, Germany, Egypt, China, Japan, the Phillipines, Hawaii, the South Sea Islands, all of the countries of South America, all of the countries of Central America, all of the islands of the West Indies, and every state in the Union.

The graduates of the Audubon Sugar School soon made a reputation for themselves and incidentally for the school. Various sugar producing countries sent special committees to investigate this school and its methods.

As I said, in the fourth year the students worked in the sugar house at Audubon Park. In the fifth year, it shortly became our policy to send them out during the sugar season into regular plantation jobs where they received the usual salary paid in those days, and did the work required. No favors of any sort were showed them. The employers were particularly requested to dismiss them if they were unsatisfactory, but no man was ever dismissed and their records were uniformly excellent. As far as I know, this was the first time in American education that the combination of practical work and theoretical training was successfully offered. I have often made the statement that it was the first course in chemical engineering offered in America and it has never been contradicted. It was also the first five year college course leading to the bachelor's degree. Herein lies the main difference from the beginning of the school under Dr. Stubbs and the new Audubon Sugar School under the University. I have often been asked to state this difference which lies mainly in the emphasis placed on the engineering side.⁴

In 1908 LSU reorganized into nine schools or colleges, each with a Dean as its head. One of the schools was the Audubon Sugar School with Charles E. Coates as Dean. In 1923 the last cane crop was planted in New Orleans at the Sugar Experiment Station and in 1924 their plots were moved to Baton Rouge. Also in 1926 the Audubon Sugar Factory was completely moved to Baton Rouge; however, in this move to Baton Rouge it was not moved to the old campus downtown, but instead to the new campus south of Baton Rouge. It had become evident by this time that there was insufficient room for the development of LSU in its campus located in downtown Baton Rouge. Room for expansion and future growth had to be found elsewhere than on the outgrown, old campus. Col. Thomas Boyd and others saw the situation very clearly. A group of business men in Baton Rouge who were friends of the University bought Gartness Plantation, a large tract of land just south of Baton Rouge and held it for the University to provide for a move to a new site. This move came during the administration of Governor John M. Parker. The first building completed on the new campus was a large stock pavilion which was named in honor of Governor Parker in appreciation of his assistance to the cause of education and LSU in particular. The people of the University were particularly appreciative of the efforts of Governor Parker in reshaping the tax structure of the state which supported education. His proposal to tax mineral resources of Louisiana was made into law and provided hitherto untold funds for the University's expansion and development. A writer of the time indicated that "a new era was begun. Gone are the days of anxiety over limited appropriations from the legislature."

In 1927 the Audubon Park facilities in New Orleans were completely closed and turned over to the city authorities. All of the activities of the early work there had now been moved to Louisiana State University in Baton Rouge.

It is very clear in reading the history of these activities in the New Orleans and Baton Rouge areas that the sugarcane industry played a very vital role, not only in the development of the agricultural and technological activities related to the sugarcane industry, but to all matters of research, development, and education in the state. The industry and its leaders made financial contributions to insure the orderly development and the success of these undertakings. It is a heritage of which the sugarcane industry may be justly proud. It also is a heritage which is carried on today.

Also embodied in all of this early history is a clear commitment on the part of Louisiana State University to meet the needs of the State of Louisiana in developing its resources. This also is a heritage of which LSU may be justly proud and which is evident today.

⁴Charles E. Coates, "Recollections of Early Days."

We will skip over the period of history between 1927 and the present. Many important events occurred during this period, of course, but there is no time to discuss them here. Instead, let us focus on the present. The sugarcane industry of today is completing a year that has been less rewarding than was hoped for. Preliminary reports indicated that per acre yields were down to approximately 21.5 net ton per acre; sugar produced will probably reach 570,000 tons raw value. Compare this to a production of 602,000 tons raw sugar and a 26.1 net ton per acre average for the 1970 crop. Fortunately, the industry was able to plant increased acreage this year because of the recent revision of the Sugar Act. The Crop Reporting Service has announced a crop value of \$67 million (without government payment) for the 1971 crop at the grower level. Income from sugarcane is at about the level of the previous year. Although growers have harvested a considerably larger acreage. The problem, of course, is that per acre yields are substantially down as a result of the damage caused by Hurricane Edith and adverse weather conditions during harvest time. It is also true that harvesting costs increased significantly and reduced the grower's net income. It is obvious, therefore, that the industry will have to implement improved production management practices to insure greater net profits in the future. Some of these are: more efficient use of herbicides to control weeds and grasses; the proper application of higher rates of plant food nutrients; cultural practices to improve cultivation and promote adequate stands; the judicious use of insecticides; careful selection of the appropriate varieties at planting time; and, of course, wise management of the industry itself. Everyone of these potential steps toward increasing greater profit represents items of concern in which LSU is able to make contributions toward improving the present situation of the industry. They represent the sort of concerns to which LSU is committed.

Focusing for a moment on LSU today, my observations will be restricted to the Baton Rouge Campus of LSU. It also has "increased acreage" under cultivation: on the Baton Rouge campus last year our enrollment was up 1,100 students; this year it is up 1,600 students -- an increase of 2,700 students or a 15% increase in the last two years. Enrollment in the fall semester was 20,600 students on the Baton Rouge Campus and 1,000 to 1,500 more are expected next fall. This requires more resources and, unfortunately, the budget from the State of Louisiana has been characterized by the state administration as "standstill." The problem is that enrollment and inflationary forces have not stood still and this has produced many financial difficulties on the Baton Rouge Campus and within the total University. I will not enumerate these for you.

In all of this, however, LSU continues to maintain its strong commitment to agriculture, and LSU is doing many things to assist the sugarcane industry directly. Consider for a moment some of these activities. An area of great concern to everyone these days relates to the ecological factors associated with the environment. Some of LSU's work is directed toward the development of varieties which are insect resistant. This will allow, of course, decreased use of chemical insecticides. LSU is also working on the "dry cleaning" of cane to reduce the necessity of burning trash and thus protecting the air. The University is working in many ways with problems of air and water pollution with which the sugar mills and refineries are concerned. Also, of course, there is the basic on-going research work with which LSU has been concerned for years. Some examples are variety development, plant breeding, plant pathology, and plant physiology. Also studies in fertility, in soil management, in water management, weed control, engineering studies, and many overall economic studies of the sugarcane industry.

Taken together it can be seen that the type of pattern developed some three quarters of a century earlier is still present today. It is a pattern in which the sugarcane industry is attempting to solve many of its own problems, and the University is maintaining and will continue to maintain its strong commitment towards developing the human and natural resources in the State of Louisiana. Embedded in this commitment is the University's strong relationship with agriculture. This reflects itself in many day-to-day activities and cooperative interfaces. The total result is a pattern which I believe insures progress for the sugarcane industry and for our State of Louisiana. None of us knows very much about the future, but based upon our history and our heritage and the manner in which we are all working together today, I think there is a bright future for the sugarcane industry, for LSU, and for the State of Louisiana.

EDITORIAL SUGGESTIONS

M. T. Henderson
General Editor

In the course of editing the papers for the 14th Congress of ISSCT and those for the 1972 meetings of ASSCT several procedures were found frequently which do not conform with the recently-adopted editorial style for the Proceedings. I would like to direct the attention of authors to a few of these commonly-occurring deviations from the editorial style which we are now attempting to establish in the hope that future papers can be edited more rapidly.

Some of the suggestions pertain to the Abstract. Authors are reminded that in the future Abstracts will be required for all papers, including those presented at divisional meetings of ASSCT. Although this may seem awkward at first, the entire Abstract should be placed in a single paragraph. The Abstract should contain specific information concerning the paper. Avoid statements to the effect that certain general types of information will be or are presented in the paper.

Place all references to publications, personal communications, etc. at the end of the paper in a section headed References. Do not use Literature Cited as the title for this section of the paper since it may contain other references than official publications. Also, do not use footnotes for references. Arrange the references in alphabetical order based on the family name of the first or senior author. Please note and adopt the style for the Reference section in papers of the current volume of these Proceedings. Use the number system for references rather than the author-year system.

When referring to a reference, place the number of the reference in parentheses at the appropriate location in the text of the paper. Do not use parentheses with any other numbers unless absolutely necessary in order to avoid confusion. Under the style being adopted a reader can assume that any number in parentheses pertains to a reference which can be found in the References section.

Authors are urged to make extensive and consistent use of commonly recognized and accepted abbreviations and symbols in appropriate situations. Do not use periods in abbreviations unless they are necessary in order to avoid confusion with other words, such as in Fig.

An attempt is being made to adopt a standard, convenient system for the designation of sugarcane varieties. The following represent examples of this system: CP 52-68, L 62-96, NCo 310. Note that all periods are omitted.

Authors are being asked to write sugarcane as a single word as a standard practice. Official titles of certain organizations, such as the American Society of Sugar Cane Technologists and American Sugar Cane League, are accepted as exceptions to this rule.

The rules for preparation of papers to be published in the Proceedings were drawn up by the Editorial Committee. However, as general editor I would like to add my whole-hearted support to them and point out that they are not intended to regiment our authors but to make the Proceedings a more effective organ for dissemination of new information pertaining to sugarcane and to raise its prestige as a publication medium for the members of ASSCT.

CORRECTIONS FOR VOLUME 1

A few errors occurred in Volume 1 of the new series of the Proceedings, containing papers presented at the 1971 meetings of ASSCT. Attention is hereby directed to these errors and their corrections:

In the Foreword, "West Palm Springs" should be "Clewiston".

On the first page of the Table of Contents, change "Jung 10-11, 1971" to read "June 8-9, 1971".

Also, on the first page of the Table of Contents under Manufacturing Section, change Production of High Quality Refined Sugar to read Production of High Refining Quality Raw Sugar and on page 70 change the title of the paper to Production of High Refining Quality Sugar.



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PROCEEDINGS

American Society
of
Sugar Cane Technologists

1973 MEETINGS

Volume 3 (New Series)

Florida and Louisiana Divisions

ASST

June 1974

PROCEEDINGS
AMERICAN SOCIETY
OF
SUGAR CANE TECHNOLOGISTS

Florida and Louisiana Divisions

Volume 3 (New Series)

June 1974

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FOREWORD

After completing the editing of the last two volumes of the Proceedings, it is apparent that at least three major problems still exist in our attempts to improve the Proceedings. One of these is the fact that some authors are not following the editorial style that has been established. The editor is probably at fault in this for my failure to make the details of the desired style more readily available to all members of ASSCT. This defect is being corrected through preparation of a style manual that will be sent to each member. Adoption of the recommended style in the writing of manuscripts is extremely important. Manuscripts that do not follow these procedures require a great deal of extra time in editing and typing, particularly the latter, and this extensive editing invites errors.

A second major problem is the considerable number of members who present papers at the meetings of ASSCT but for various reasons do not submit manuscripts of these oral presentations for printing in the Proceedings. Of 54 papers which were presented orally at the three meetings held in 1973, complete manuscripts were received for only 41. Fortunately, most of the papers without complete manuscripts were presented at the joint meeting of the two divisions and, consequently, abstracts of these papers were available for the Proceedings. However, abstracts are not as suitable as complete papers, and authors are urged to submit manuscripts of all papers presented at the three annual meetings of the Society.

Another problem, related closely to that described in the previous paragraph, pertains to panel discussions and symposia. As a general rule, information presented at these discussions is not placed on record and submitted for printing in the Proceedings. However, this information would be of interest and value to many readers, and the organizers of these panel discussions are requested to make some provision for inclusion of the information in the Proceedings.

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PROGRAMS OF ASSCT MEETINGS FOR
1973

Program of Third Annual Joint Meeting
Pensacola, Florida
June 14 - 15, 1973

June 14
Morning Session

Registration

Plenary Session

Welcome

P. M. McIntyre
President, Florida Division
Connie Melancon
President, Louisiana Division

The Future of the Louisiana Sugar Industry

James H. Thibaut
President, American Sugar Cane League

The Florida Sugar Industry: Its Progress, Problems, and Opportunities

Nelson Fairbanks
Vice President, Florida Sugar Cane League

Report of General Secretary-Treasurer

Denver T. Loupe

General Business

Afternoon Session

Joint Meeting of Agricultural and Manufacturing Sections

Chairman: Edwin R. Rice

Papers:

Problems in Implementing Mechanical Sugarcane Harvesting in Florida - Joe E. Clayton and William C. Hedick, Jr.

Mechanical Harvesting and its Effect on the Factory at Talisman Sugar Corporation - J. Castro and J. Balerdi

The A. Duda and Sons Mechanical Furrow Stalk Chopper - Gene Dodgen

Evaluation of Pre-Harvest, Foliar-Applied Chemicals for Sucrose Enhancement in Florida Sugarcane - J. R. Orseniga and S. L. Hooks

Testing Chemical Ripeners for Sugarcane in Louisiana - B. L. Legendre

Sucrose Enhancement with Polaris in Sugarcane - K. R. Frost, Jr.

Fallow Flooding for Control of Johnsongrass in Sugarcane: Effect of Bagasse Application and Time and Depth of Flooding - J. F. Parr, M. M. Mayeaux, C. R. Camp, and R. B. Carroll

The Use of Chemical Herbicides to Control Johnsongrass in Louisiana Sugarcane - Ernest R. Stamper

June 15
Morning Session

Agricultural Section

Chairman: P. J. deGravelles, Jr.

Papers:

Production of True Seed from Basic Lines of Saccharum and Related Genera in New Crosses at Houma, Louisiana - P. H. Dunckelman

- ✓ A New Method of Synchronization of Flowering in Sugarcane - Elias D. Paliatseas
- ✓ Selection of High Sucrose Experimental Clones from Single Stool Brix Data - C. A. Richard and M. T. Henderson
- ✓ CP 65-357, A New Sugarcane Variety for Louisiana - H. P. Fanguy
- ✓ Breeding for Resistance to Mosaic Strain H in Louisiana - R. D. Breaux and P. H. Dunckelman
- Mixed Infections of Sugarcane with Sugarcane Mosaic Virus and Maize Dwarf Virus - H. Koike
- The Recovery of Sugarcane from Infection with Sugarcane Mosaic Virus: Variety Co 285 and Strain D - G. T. A. Benda
- Rate of Planting on Yield of Sugarcane Infected with Mosaic - R. J. Steib and S. J. P. Chilton
- The Effect of Fungal Isolates from Sugarcane on Seedpiece Germination - Shaw-Ming Yang
- Evaluation of Sugarcane (Saccharum sp) Selections for Eye Spot Resistance - J. D. Miller

Manufacturing Section

Chairman: F. J. Blanchard

Papers:

- Frost vs Cane Juice Acidity - Cane Supply Line Inspection - James C. P. Chen, Robert W. Picou, and G. T. Blanchard
- ✓ Evaluation of Post-Freeze Cane Juice Quality - James C. P. Chen and John J. J. Chen
- Solid State Controls for Sugar Centrifugals at Glades Sugar House - A. L. Ballard, L. Gandia, and R. R. Burns
- Solid State Centrifugals Battery Sequencer at Glades Sugar House - A. L. Ballard and L. Gandia
- Automation - G. Aleman, A. Arvesu, and C. Reynaldos
- The Apparent Purity and the Exhaustion of Final Molasses - Armando Acosta
- Particulate Sampling in a Louisiana Cane Mill - Chester C. Watson
- Aspects Which Affect Clarification and the Remedies Used at Greenwood Factory - Gary J. Labat
- Pneumatic Conveying of Bulk Bagasse in Louisiana - Albert I. Guidry

Afternoon Session

Joint Meeting of Agricultural and Manufacturing Sections

Chairman: Enrique R. Arias

Papers:

- Effects of Inter-Row Spacing on Sugarcane Yields in Louisiana - R. J. Matherne
- Maintaining Maximum Yields with Skip Planting - J. W. Beardsley
- Yields and Nutrient Element Content of Roots and Below-Ground Stubble as Related to Fertilization of Sugarcane and Soil Variation - Laron E. Golden
- Leaf Sheaths and the Germination of Young Axillary Buds in Sugarcane - G. T. A. Benda
- ✓ Estimating the Total Leaf Area in Sugarcane Varieties - J. E. Irvine
- Florida Sugarcane Attacked by White Grubs - T. E. Summers
- Mass Rearing the Sugarcane Borer - R. D. Jackson
- ✓ L 60-14, A Tropical Sugarcane Variety - M. Coromel, F. Chui, and S. J. P. Chilton
- The Effect of Frost on Certain Sugarcane Varieties Grown in the Rio Grande Valley of Texas - K. A. Sund and B. A. Smith

Program of Fourth Annual Meeting of the Florida Division
Clewiston, Florida
October 11, 1973

Registration

Welcome

P. M. McIntyre
President, Florida Division

Manufacturing Section

Chairman: Enrique R. Arias
Papers:

Multiple Effect Evaporation: A Simplified Method of Calculation - Ernesto del Valle

Conditions Affecting the Low Grade Work in a Cane Sugar Factory - Gerardo F. Fundora

Sugar Exhaustion by Massecuite Cooling - Guillermo Aleman

Symposium: Liquid Effluents Disposal Problems in the Cane Sugar Industry - Frank S. Kleeman,
James I. Goodson, Jr., and Richard H. Jones

Agricultural Section

Chairman: Edwin R. Rice
Papers:

Field Losses and Trash Content of Hand-Cut and Mechanically-Harvested Sugarcane in Florida -
Joe E. Clayton, Glenn A. Zepp, and William C. Hedick, Jr.

Costs for Mechanically Harvesting Sugarcane in Florida - Glenn A. Zepp and Joe E. Clayton

Maintaining Maximum Yields with Skip Planting - J. W. Beardsley

Panel Discussion: Labor - New Regulations - C. C. Davidson, Fred C. Sikes, and George Sorn

Program of 1973 Annual Meeting of Louisiana Division
Baton Rouge, Louisiana
February 1, 1973

Registration

Call to Order

Connie Melancon
President, Louisiana Division

Agricultural Section

Chairman: R. J. Matherne
Papers:

Trash Sampling Studies at Louisiana Sugarcane Mills - D. P. Viator

What Causes Trash? - F. N. Bolton

Some Effects of Trash on Milling Quality of Sugarcane - B. L. Legendre and J. E. Irvine

Deterioration in Whole and Chopped Sugarcane - J. E. Irvine and B. L. Legendre

Mechanical Harvesting in Louisiana: The Effect on Cane Quality and Processing Response -
1972 Studies - John J. Seip and Jorge A. Salazar

Manufacturing Section

Chairman: Bradley Kimbrough
Papers:

Corrosion-Resistant Concretes and Mortars for the Sugar Industry - William Netter

Operation of an Anti-Fouling Evaporation Process Pilot Plant at the Raceland Factory of
the South Coast Corporation - Jay Dornier

Core Sampling of Louisiana Sugarcane - 1972 Studies - Harold S. Birkett and John J. Seip

Cane Washing at Lula Factory - C. J. Daigle

Reuse of Sugar Mill Waste Water - James E. Nugent

Business Meeting

Address: A. W. Cooper
Deputy Administrator
ARS-USDA

PAPERS PRESENTED AT THIRD ANNUAL JOINT MEETING

Pensacola, Florida
June 14 - 15, 1973

THE FUTURE OF THE LOUISIANA SUGAR INDUSTRY

James H. Thibaut
President
American Sugar Cane League

A trait common to most humans is our inability to view problems and opportunities with a proper perspective. We are usually so involved in dealing with our problems that we get a distorted picture of our present situation and the outlook for our future.

In preparing for this talk, I first made a list of problems of the Louisiana sugar industry. After the list was completed, I felt that I should look for another occupation.

Then, I made a list of things which encourage me with respect to the future of the Louisiana sugar industry. I felt better. My perspective had been restored.

THINGS I WORRY ABOUT

Here are some of the things I worry about. First, the Sugar Act, which plays a large part in controlling the destiny of the sugar industry, expires at the end of next year. There is little doubt that Congress will amend and extend the Act. But I worry about whether the new provisions with respect to marketing quotas, proportionate shares, and the sugar price will allow our industry to survive and prosper.

State and Federal regulations on the control of air and water pollution concern me. The technical aspects of reducing pollution and the costs involved can create insomnia.

But we can make use of our sleepless nights by reading the 257 pages of fine print which constitute the regulations issued under the Occupational Safety and Health Act. After several readings of these regulations, you may have a vague understanding of what you read and a clear understanding that some requirements make no sense. Compliance with them will be costly and will not contribute materially to the health and safety of employees.

Speaking of employees, I can be a worrywart about them, both factory and farm employees. Are enough technical people being trained for our future needs? Will we be able to attract enough unskilled and semi-skilled workers to meet our future needs?

When we run short of things to worry about, we can always turn our attention to the weather. In this area, we have a wide variety of choices. We can choose hurricanes, excessive rains, floods, droughts, freezes, or you name it.

A relatively new worry for all of us is the energy crisis. Will Louisiana cane factories have natural gas in future processing seasons or must we shift to some other fuel? If gas becomes unavailable, will an alternative fuel be available? Can we afford the ever increasing cost of natural gas and other fuels? If I had to single out any problem which I view with some alarm, this is it. I can't help but feel that we are entitled to our share of natural gas, especially since much of it comes from under sugarcane lands.

The processing capacity of cane factories is of real concern to both processors and cane growers. The cost of building a new factory is prohibitive. The cost of expanding the capacity of an existing factory is rapidly becoming almost prohibitive.

In Louisiana, we are continually losing good cane land to other uses, such as industrial, commercial and residential. This bothers me. When we compensate for such losses by bringing new land into cane production, this usually involves an expenditure for clearing and draining. The expenditure is heavy and so is the land in most cases.

The last of my worries I'll mention (not the last that I have) is the continuous reduction in the number of cane farmers. Normally, when a cane grower quits farming, his land is taken over by a neighboring farmer. This is usually good for the neighbor because it gives him a more efficient size farming operation. But, looking at the total picture, the reduction in number of farmers tends to lessen our industry's influence in the State Legislature, in Congress, and elsewhere.

THINGS WHICH ENCOURAGE ME

Now, I'll tell you things which encourage me. First, I get much comfort from reviewing the history of the Louisiana sugar industry. There were many times during the last 178 years when the industry faced problems more severe than those we now face, and yet the industry survived.

I find comfort in the spirit of cooperation between the various groups interested in the Sugar Act. This includes all segments of the domestic sugar industry and the industrial sugar users, who buy three-fourths of the sugar sold in the United States. I think we will succeed in 1974, as we did in 1971, in getting a new Sugar Act which will be good for all of us and the sugar consumers.

In a broader area, there is reason for all of us to be happy and optimistic about the growing cooperation among varied agricultural groups of the United States. One demonstration of this cooperation is the formation and growth of the National Agricultural Institute. This is an organization formed in 1970 by the Florida Sugar Cane League, the American Sugar Cane League, and just a few other agricultural people. The National Agricultural Institute's sole function is to do a public relations job for American agriculture. Many other farm groups are now participating. Even more encouraging is the fact that many agricultural suppliers are now a part of this movement. The success of this movement is vital to all of us engaged in agricultural activities. We represent a dwindling percentage of the total U. S. population, and it is important to us that the general public understand that food does not originate in the grocery stores.

Last year, the sugar people of Louisiana and Florida and the cotton people demonstrated what cooperation can do when we persuaded Congress not to enact some Fair Labor Standards Act amendments which were advocated by labor unions and which would have crippled the sugar and cotton industries. We are engaged in the same battle this year, and although we have lost a few skirmishes, we hope to prevail.

While on the subject of cooperation, I must express my appreciation for the great degree of cooperation, in many areas, that exists between the Florida and Louisiana sugar industries. The vehicles for many of our joint efforts are the Florida Sugar Cane League and the American Sugar Cane League. And, of course, another important such vehicle is this society, the American Society of Sugar Cane Technologists. I urge that you continue your good work.

Another source of encouragement to those of us in the Louisiana sugar industry is our excellent research program. I think you in Florida can make a similar statement. Much of our research involves cooperative participation between the USDA, the Louisiana Agricultural Experiment Station, and the American Sugar Cane League. We hasten to add that we benefit from the free exchange of information among all cane areas of the world. I don't think I am immodest for thinking we also contribute toward that exchange of ideas.

A contributing factor toward a bright outlook for all of us in the sugar business is the steady increase in sugar consumption, in the USA and in the world. This increase is due not only to population growth but to an increase in per capita consumption, particularly outside the USA. It is remarkable that there has apparently been a slight increase in per capita consumption of sugar in the USA in spite of all the spurious attacks on sugar.

To the young people in the audience, I want to say you do more to give a rose-colored tint to my glasses than anything else. Your faith in the sugar industry gives me courage and makes me confident about our industry's future.

If you young people haven't already learned, you will learn that sugar people are a special breed. The generations of sugar men who preceded us were men of character who met and conquered adversity and continued building and improving their industry. Those of us presently wrestling with the problems of sugar are trying to live up to the example of our predecessors. I'm sure you younger people who pick up where we leave off will continue the tradition of building and improving your industry.

I'm certain the young people already know that sugar people not only work hard, but we play hard too. There is lots of fun in the sugar business. It's not all problems.

I think the Louisiana sugar industry has a great future. Louisiana will continue to grow and process sugarcane. Why? Because we have about 500,000 acres of cropland that are better adapted to the growing of sugarcane than any other farming enterprise. Further, we have an industry that is pretty well mechanized; one that has already lived through a good part of the horrors of mechanical harvesting. I believe we are in better position, competitively--economically, in relation to other areas of sugar production than when I came into this business about 25 years ago. When I think back to the kinds of sugarhouses and field equipment we had in Louisiana in those days, I shudder to think where we would be today if our technology had not been able to bring us along as it did. I think this trend will continue and we will get steady improvement in the equipment we use.

I look for no large increase in Louisiana's cane acreage unless something happens to make the growing and processing of cane more profitable or unless we develop more cold tolerant varieties that would allow the cane area to expand northward in the state. We are working towards both of those ends.

Profits could be increased by better varieties, new farming practices which would increase cane and sugar yields per acre, new cost saving practices, or by a higher price for sugar. I am not optimistic about the prospects of the development of any spectacular new cost saving practice or about the price of sugar rising faster than prices of things we buy. That leaves us with the fact that we must increase sugar production per acre by better varieties or by some new farming practices.

In our regular variety development program, we already have unreleased varieties in various stages of selection and testing which we believe will give us moderate increases in sugar per ton of cane and slight increases in cane per acre. For any dramatic improvement in our varieties, we must look to the basic breeding program now under way at Houma and Canal Point. We think this program has increased our chances of a break-through in the development of varieties which will produce more cane per acre and more sugar per ton of cane. There is already evidence that this program may develop varieties with more cold tolerance, which would allow an expansion of our cane growing area.

Processing capacity is now a problem in some parts of the Louisiana cane area and will likely become a greater problem in the future. Because of this, I expect some of the independently owned mills in Louisiana to become cooperatives, in order that the costs of further capacity-expansion may be spread among more people.

In conclusion, I'll say that I'm optimistic about the future of the Louisiana sugar industry, in spite of our many problems. I'm happy to be in the sugar business--and to be associated with the remarkable people who run it.

THE FLORIDA SUGAR INDUSTRY:
ITS PROGRESS, PROBLEMS, AND OPPORTUNITIES

J. Nelson Fairbanks
Vice President & General Manager
Florida Sugar Cane League

It's a pleasure for me to talk to you today about the Florida sugar industry. I always look forward to this Joint Annual Meeting and visiting with many of my Louisiana friends. As you understand, I have more than just a casual interest in this meeting. As a native Louisianian once a member of the Louisiana sugar industry, and having actively worked to help organize our Florida Division, I am always looking forward to this meeting.

When Dr. Chilton first contacted me about being on the program, he asked that I discuss problems of the Florida Industry. Although we have some problems in our industry, I think the progress we have made and the opportunities which lie ahead should be included in any general discussion of the industry.

Therefore, I wish to present my remarks under the heading of "Progress, Problems and Opportunities." Within this outline I will touch the broad aspects of our industry.

1972-1973 CROP

Florida just concluded its largest, longest and most successful harvest. Final production figures show that the 8 Florida mills ground 9,888,939 tons of cane and produced 960,562 tons of raw sugar and over 68,000,000 gallons of blackstrap molasses. This is 34% more sugar than the previous record of 717,000 tons produced from the 1967-68 crop and 51% more than the previous year's production. Although the yield of 9.54% sucrose (96° sugar as % gross cane) was lower than normal, the tonnage of cane, which averaged almost 40 tons per acre, more than made up for the lower sucrose.

Weather, of course, was the primary reason for the significantly increased tonnage of cane. For two consecutive winters South Florida has sustained only light frosts and consequently there was little damage to the young cane and virtually no damage to the old cane. This made it possible for a very long grinding season. Statistics show that the mills averaged 171 crop days, ranging from 145 to 220 days. The 220 day crop at Talisman set a record for the longest grinding season in Florida history, surpassing the 203 days which Clewiston operated in 1942-43.

Although weather played an extremely important role in cane production, there were some other factors -- factors which many of you helped create. Before we discuss these man-made inputs, let's look briefly at the trend in Florida's production from 1962 to 1972.

During this period, Florida increased from a 1962 low of 380,000 tons to a record 960,000 tons in 1972. There were 3 government-imposed acreage cuts during these years, and for the most part the dips in annual output were results of these acreage reductions. In addition to total production having a rather significant upward trend, sugar per acre also tended to trend upward.

Sugar per acre during this '62 to '72 period ranged from 2.58 tons to 3.83. The lowest yield per acre was in 1964 and the highest was in 1972.

It is interesting to note that for any 3-year period during the last 11 years, the yield of sugar per acre was higher than the immediately preceding 3-year period. For example, the yield for the 3-year period 1964 to 1966 was 2.93 tons and the next 3 years it was 3.31 tons. In the last 3-year period the industry averaged 3.55 tons per acre.

This indicates, that factors such as new varieties, improved farm management, and increased milling efficiency played a significant role. And those of you doing the research, supervising and directing the planting, cultivating and harvesting, together with the engineers, chemists and technicians in the mill, deserve the credit for this increase in efficiency.

Reemphasizing this past season was abnormal and cannot be expected to reoccur often, I think it is quite possible that total production will increase and sugar per acre will continue to trend upward. The long processing season we enjoyed this past year cannot be counted on every year. In order to be safe, most mills must shorten their grinding season. To do this will require an increase in milling capacity at several mills. This has been taken into consideration and there will be additional capacity provided.

Having recounted and summarized the best season on record, let's get to the problems which we are trying to solve and must solve if we are to continue to progress.

MECHANICAL HARVESTING AND PLANTING

Broadly speaking we must reduce our labor needs and costs in the future. At the top of the list must be the successful development of mechanical harvesting and planting.

We are making progress in mechanical harvesting, but we still have a way to go before the industry is totally mechanized. Over the last few years, several of our sugar companies have launched their own programs with the goal of total mechanization in the future. It takes time to make an orderly transition, and, even though we are moving in that direction, each year there are significant modifications made on these machines; therefore, with the exception of one company, we still consider mechanical harvesting experimental in Florida.

Last season we cut just under 1.5 million tons of cane mechanically in Florida, or almost 15%. Of this total, however, over 1.1 million tons was cut by Talisman. Excluding this company, only about 4.3% of the remaining cane was cut mechanically. The previous year we cut about 2 1/2%.

This amount will increase next season but I don't know exactly how much at this time.

Even though progress has been made in trash removal, we still have the problem of top removal. What scares everyone is the early freeze. With hand cutting, frozen tops can be removed with minimum loss of sugar, normally for several weeks after the freeze. But with Florida's recumbent type growth the machines we now have are unable to successfully do this job. We really don't know what the situation will be until we experience an early freeze. I hope one doesn't occur soon.

LABOR PROBLEMS

As most of you are well aware, the United Farm Workers Union filed suit last year to stop our off-shore labor program. They were unsuccessful, but throughout the season we were harrassed by their organizers. We redoubled our efforts to recruit American workers to cut cane this past season. This was done at considerable expense throughout the USA. We were unsuccessful in getting Americans to come and work in the fields. Although we anticipated this would be the result, we thought the recruiting was necessary.

The workers we got to cut cane were either organizers or sympathizers with the UFW and only interested in the publicity that occurred. As in the past years, the time period worked by these persons was short and their productivity terrible.

We know American workers will not cut cane and offshore workers will be needed until full mechanization can occur.

An orderly and gradual transition to mechanical cutting is the only practical way to proceed. If permitted to make the transition gradually, the chance of success without great loss or production is possible.

Cane planting is also a labor intensive operation in Florida. Because of the relatively short planting period and high peak labor requirements, there is always a scarcity of labor. A few years ago we received certification for offshore labor to plant cane. During the last 2 years certification has been received late during the season. This has forced us to plant at a slow pace using what domestic workers that could be found. The productivity of planting has, therefore, greatly declined.

Within the last 2 or 3 years, some progress has been made in the development of planting aids. This increases labor productivity somewhat but is really not very significant in terms of peak season workers required.

We all hope that more progress can be made in the development of a planter. Several companies are working on this.

LAND SUITABLE FOR CANE PRODUCTION

We don't have unlimited land suitable at this time for sugar cane production in Florida. Therefore, to increase overall production, we need to continue to improve our sugar per acre. New, improved varieties are the main way this can be done. There are other ways and it's a matter of economics as to how far you can go to increase sugar per acre. Some have done it through shorter rotations. Recently there has been some interest in skip-planting poor stubble fields. Such an operation should require less seed than normal replanting and reduce the rotation land. The overall yield per planted acre may not be increased by this method but fallow land would be reduced. This is experimental but may be worth pursuing on this basis. To do this, an economical replanting method would have to be found.

ENVIRONMENTAL QUALITY

Another factor which must be included under the list of problems facing the Florida sugar industry is the increased costs of complying with pollution control laws. We have made significant progress in testing and developing the emission control devices on mill stacks, and as a result of this work the State of Florida Department of Pollution Control recently approved one of the units we tested as the "best available technology."

Even though the cost will be considerable, each of the Florida mills plans to install one such scrubber for the next crop. By the 1975 crop the Florida mills have agreed to a compliance schedule requiring that all stacks be equipped with these wet scrubbers.

According to data from the pollution control officials, emission from our stacks account for roughly half of the industry's total emissions. Therefore, we feel we will be making a real contribution to a cleaner environment when these units are operational.

While on the subject of environmental quality, I want to touch on field burning. Occasionally I am asked, mainly by persons outside the sugar industry, when we expect to stop burning cane prior to harvest. I think the best answer is that we are complying with the regulations on open burning and the air quality is good. We have reduced our emissions through controlled burning and the only other thing we can do is try to develop a green-cane harvester. As most of you know the task of developing a mechanical harvester to successfully harvest burned cane has been long and hard. We've not yet solved this problem, but, when we do, we can direct our full energy and resources toward this ultimate goal.

In the meantime I should emphasize that our studies show that the air in and around the sugarcane growing area is high quality and well within the limits prescribed under the Federal Clean Air Act.

OPPORTUNITIES AND OUTLOOK

We all recognize the major problems that face the industry. Even though some of these are formidable, the opportunities for expanded sugar production exist.

It now appears that Florida's opportunity to share in the increased quotas granted by Congress in the 1971 Sugar Act Amendments is greater than anticipated at that time. With the anticipated growth, Florida's marketing opportunities should soon reach 1,000,000 tons annually.

There are some other basic barometers which should indicate the direction we might pursue.

First is the world sugar picture. Production has not kept pace with rising consumption. Ups and downs are normal occurrences in world sugar production, but with demand increasing rapidly in some parts of the world, not only in sugar but many other foods, resources are likely to be spread out. Sugar production may not expand as it normally does following a price rise.

Second, there is no real push for expansion in the domestic producing areas. With shortages of grains in the world and prices of such crops as soybeans looking very attractive, some beet farmers may switch to other crops.

Third, per capita consumption in the USA has increased and appears to be holding at this higher level. With the demise of cyclamates and the fate of saccharin uncertain, the development of new sugar substitutes may not be an attractive investment.

So, the outlook is good for sugar production. With the Sugar Act coming up for renewal next year, I think consumers in the USA will be anxious to see greater domestic production.

I'm not going to make a forecast at this time regarding potential production in Florida. A few of us have prognosticated in the past on a million ton production. We missed that by less than 40,000 tons this year so the realization of this prediction seems almost certain to happen in the near future.

Therefore, the opportunity for orderly growth seems evident, and I believe we will meet this challenge.

PROBLEMS IN IMPLEMENTING MECHANICAL SUGARCANE HARVESTING IN FLORIDA

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ABSTRACT

Mechanical sugarcane harvesting has been in the experimental stage for the past 10 years in Florida, but commercial machines were operated this season. About 15% of the crop was mechanically harvested this year, while only 2.6% was mechanically harvested the previous season. One producer harvested his entire crop mechanically, using 23 harvesters purchased from Australia. The large amount of tops and leaf trash in the mechanically harvested cane is detrimental, and some of this trash is being removed by suction fans on the harvester. Other problems include uprooting of cane during harvest and poor flotation of the heavy machines on the muck soil. The increased use of mechanical harvesters has shown that they must be grouped into large harvesting units for proper organization and coordination. More operators are needed and higher skills are required for mechanical harvester operations than are required for continuous loader operations. Considerable information has been gained during this season, and certain components of the harvesters will be made more durable. Operating problems will be corrected, and suitable operators and mechanics will be trained. It is expected that an even larger increase in the percentage of sugarcane mechanically harvested will be made next year.

INTRODUCTION

The season 1972-73 is considered to be the first in which mechanical harvesters have been used to harvest sugarcane commercially in Florida, following about 10 years of experimental development. One Florida producer harvested his entire sugarcane crop mechanically, using 23 gathering-type harvesters purchased from Australia. During this season, about 40 harvesters were in operation and almost 1,500,000 tons of sugarcane, or approximately 15% of the crop, was harvested mechanically. During the previous season, about 15 harvesters were operated, and approximately 2.6% of the crop was harvested mechanically.

The problems that have been observed over the past few years and some new ones which have become evident this season will be discussed in this paper. Much experimentation is still being done on components of several of the sugarcane harvesters, and much is yet to be learned on proper organization, maintenance, and operation of the machines in a harvesting unit.

DESCRIPTION OF SUGARCANE HARVESTERS AND TRANSPORT

Two district types of mechanical sugarcane harvesters are being used in Florida -- the mat-type and the gathering-type.

The mat-type harvester has been under development for about 10 years. This machine has a wide pickup system which harvests a 5- or 10-foot width. The area being harvested is cut by a side knife to separate the row of sugarcane. The short pieces fall into the next row and are picked up by the harvester on the next pass through the field. The mat-type harvester is usually a heavier machine than the gathering-type machine and has more components. The mat-type system usually cannot cut the pieces as uniformly, and pneumatic cleaning is not as efficient. The cane is moved through the machine at approximately ground speed, and movement of the cane is held to a minimum.

The gathering-type (Australian) harvester separates and divides the row without side cutting. Vertical shields inside the scroll-type dividers force the tops of the stalks forward and guide the material into a narrow throat. The stalks are cut at the ground by a rotating disc and are pulled base-first into the harvester by upper and lower feed rolls. The chopping knife, for cutting the stalks into short pieces, is located immediately behind the feed rolls.

The gathering-type harvester is usually lighter and simpler than the mat-type harvester. Since the stalks are aligned in the machine, they are chopped into more uniform lengths than is accomplished by the mat-type harvester, which allows better cleaning and more dense loading in the wagons.

However, this type of harvester has more difficulty in harvesting tangled or brittle cane or cane having loose root systems because of the soil conditions. If the row cannot be divided easily, the stalks may be uprooted or broken by the gathering devices. The short, broken pieces are difficult to recover by this machine on the next row.

The following general types of harvesters were used in Florida this year:

<u>Harvester</u>	
One-row, mat-type--rubber tires.....	8
Two-row, mat-type--track mounted	8
One-row, gathering-type--track mounted	23
One-row, gathering-type--rubber tires	7

During the year, all harvesters in Florida were equipped with suction fans to remove trash from the cane pieces on the conveyors. The new gathering-type harvesters have chopping mechanisms which cut the cane and trash short and provide very uniform pieces. The chopping devices have been improved on the mat-type harvesters to produce a thorough cut and more uniform pieces. Efforts are being made to thin the flow of cane on the harvester, to locate the suction fans for optimum cleaning, and to discharge the trash away from the field or wagon.

Because the cane is cut into short pieces, the transport equipment that receives the cane from the harvester conveyor must be fully enclosed with sides of metal or steel mesh. The containers should be dumped from a ramp with a dumping mechanism that will not cause excessive spillage of the short pieces. The field wagon should be long so that the harvester and wagon synchronization can vary without spillage.

Fortunately, the Florida sugarcane area already has transportation and handling equipment for short-length cane. This equipment can be used with the mechanical harvesters, and the cane may be hauled to the mill in wagons or loaded into trucks or rail cars by transload station conveyors.

The producer who harvested all of his crop mechanically used a system in which 40-foot highway trailers were towed beside the harvesters in the field by a tractor. The trailers were modified for this use by adding a third dual axle to the rear and lowering the sides about 2 ft to fit under the harvester conveyor. A triple-axle dolly supported the front of the trailer as it was towed by the tractor. A crawler tractor was available to push the large trailer through soft spots. The loaded trailer was connected to a highway truck-tractor and hauled to the mill by a contractor.

The cut-and-load harvesting system has proven successful in several sugarcane production areas for cutting fallen, or recumbent, cane that is harvested annually. The crooked stalks are difficult to handle mechanically, but when cut into approximately 12-in. pieces they may be conveyed with chain-slat conveyors and will load with reasonable density into the transport equipment. The cane row must be level, or on a slight ridge, for satisfactory operation of most harvesters.

Good coordination, scheduling, and management of the mechanical harvesters, field transport equipment, and road transport equipment are essential with the cut-and-load harvesting system. A breakdown in any of these functions results in successive stoppage of all harvesting and milling, unless there is storage at the mill. These factors make it advantageous for the harvesters to be grouped into large operating units to be closely coordinated with the mill.

SUGARCANE HARVESTING PROBLEMS

Many of the harvesting problems concerning the sugarcane crop and the harvesting machines are a result of the muck soil in Florida. Probably the most detrimental factor is the recumbent growth of the cane, which causes the stalks to be interlocked across 2 or 3 rows. In the majority of the fields, the tops are only 3 to 5 ft above the ground, with only a few stalks erect. The stalks cannot be erected for topping without being broken or uprooted in the process.

It is estimated that only about 25% of the stalks in Florida are in a position for mechanical topping. In many instances, the harvester operator does not have time to make the rapid changes in topper height, and the topper remains in a position for erect stalks. Mechanical topping is not practical in fields in which all the cane is recumbent; therefore, the topper is not operated in such fields.

The soft, muck soil will not support the root system of the recumbent cane plant while the plant is gathered into the harvester. Therefore, the stalks must be cut from the ground as the row is being divided and must be lifted into the harvester feeding mechanism. Relatively flat cultivation is required for the mechanism to pick up the recumbent stalks and short pieces from the ground. Some roots are removed with the best harvester operation because some stalks become uprooted during the growing season.

The flotation of the harvesters wheels or tracks is poor on the Florida soils. Most harvesters are mounted on tracks for sufficient support during operation in wet fields or soon after a rain. The harvesters that are mounted on wheels usually run over the stubble because of the wide tires. The repeated trips over the field by the harvester and wagons are detrimental, especially during wet weather.

The row must be kept flat to reduce the incidence of muck fires, which start in the dry soil around the roots. With hand cutting, the cane is usually cut in one day and the water wagon can be pulled between the windrows to extinguish fires. It generally takes 2 days or more to harvest a field mechanically so the fires may burn longer and do more damage than at present.

SUGARCANE TRASH CONTENT

In the fields of recumbent cane, where no topping can be done, the harvester may gather all of the green trash in the field, which amounts to 20 to 25% by weight. The cleaning fans remove some of the leaf and top, but the trash in the harvester sample is often between 10 and 20%. The trash content depends more on the maturity of the field and the amount of preharvest burning than on the harvester. The cane harvested by 2 producers who used mechanical harvesters this season had an average trash content of 7 and 11%. With hand cutting, the trash content has generally averaged 5 to 6%.

The tops of sugarcane in Florida are relatively immature and cause severe processing difficulties at the mill. Another problem is that these tops are additional material which must be transported, and the leafy material reduces the capacity of the transport equipment. There were no frozen tops on the cane in Florida this year, but in many years their reduced quality from freezing would be additionally detrimental if they were not removed.

There is no development work being done on cleaning the cane at the transfer point or at the mill at the present time. In addition to the mechanical problems, the removal or disposal of the trash from the cleaning station is a major difficulty. The one-row harvester conveyor has the lowest rate of flow of any point in the cane-handling system in Florida. Efforts are being made to thin the material on the conveyor so that air can pass through it to do the cleaning on the harvester. The harvester could be operated at low speed to allow a thinner flow when cleaning is of paramount importance.

OTHER CONSIDERATIONS

The degree of deterioration caused in short-chopped cane by mechanical harvesters is still unknown in Florida and depends upon weather conditions. Deterioration of mechanically harvested cane has been a severe problem in other areas and will likely be a problem in Florida under some conditions. Sharp knives should be used in the cutting mechanism of the harvester, and the cane should be milled within 24 hr after cutting. Until more is known about deterioration, mechanically harvested cane should be given priority at the mill, and should not be put in storage.

Mechanical harvesters generally cut one row and load at the rate of about 60 tons per hour, while the continuous loader takes 4 rows and loads at about 300 tons per hr. For a harvesting unit loading 1000 tons per day, considerable additional transportation equipment is needed for the harvesters due to the extended loading time. The transport time will also be increased by low tonnage fields and small fields where many rows will be covered and more turning time is required. Therefore, about 20% more field transport equipment may be necessary for the average mechanical harvester operation.

Three or four mechanical harvesters will be required to equal the production of one continuous loader in the present harvesting unit. Three or four more operators, tractor drivers, or mechanics will be required for the mechanical harvesters than for continuous loaders. These men will need training to acquire the higher skills they need in making adjustments and in operating and maintaining components that are not familiar in present operations. It has been difficult to get vehicle and tractor operators this year, and it may also be difficult in the future to get qualified people who will work in the dirty field operations.

On the plus side, mechanical harvesters now load cane into transport equipment as densely as the continuous loader does. In some instances, when the cane is chopped short and trash is removed, mechanical harvesters can load more cane into transport equipment than the continuous loaders can.

It is evident that the mechanical harvester is cutting the cane closer to the ground than the hand cutter and is recovering these high-sugar pieces of cane. In many instances, the harvester samples contain higher sucrose and more tonnage per acre.

However, the early season immature tops, late season sprouts or suckers, and frozen tops will make total sugar recovery lower than with the present method.

The cost of machinery and labor for mechanical harvesting will be less than for hand cutting, but field damage or quality losses from mechanical harvesting may result in costs being about equal. Mechanical-harvesting costs should decrease as machines are used more extensively, but there is little possibility that costs of hand cutting will decrease.

DISCUSSION

Observations of field and harvesting conditions for the past 10 years indicate that the possibility for mechanical harvesters look good. Fields are being smoothed, and rows and turning areas are much more uniform than in the past. The newer varieties of cane are more uniform, have a better stand, and shed the trash or have less green trash. In some instances, the rows have been lengthened, the fields made narrower, and space left for opening the field at the sides or in the center.

At the same time, the work of the hand-cutter has become poorer. The stubble is left high, cane is left uncut below the pile row, and the stalks are not topped properly. These conditions cause poorer efficiency of the continuous loader, and more cane is being left on the ground. Therefore, we are rapidly approaching the point where the quality of cut and quality of product for hand and mechanical cutting will be similar.

Several of the harvesters developed in Florida have proven successful. They are grouped into larger units, and the production is scheduled by the mill. Some of the Australian gathering-type harvesters are successful under most Florida conditions, and some are adaptable to the lighter tonnage fields. The cane is loaded into transport at the time of cutting, so fresher cane is generally available with mechanical harvesting than with hand cutting.

None of the harvesters will operate effectively in unburned recumbent sugarcane. The dry trash on the ground blocks the view of the operator, and he cannot stay on the row or adjust the cutter properly. The loose trash accumulates on the dividers and in the feed rolls, causing chokages. The bulk of dry trash reduces the capacity of conveyors and transport drastically. In addition, the trash is a severe fire hazard around harvester and tractor engines, and may cause the machines and fields to burn.

Considerable progress has been made and much has been learned in Florida during this year of increased mechanical sugarcane-harvesting. As a result, components of the harvesters will be made more durable, operating problems will be corrected, and suitable operators and mechanics will be trained. It is expected that an even larger increase in the percentage of cane mechanically harvested will be made next year.

MECHANICAL HARVESTING OF SUGARCANE AND ITS EFFECT ON THE FACTORY
AT TALISMAN SUGAR CORPORATION

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Belle Glade, Florida

In the 1972-73 grinding season Talisman Sugar Corp. changed from handcutting to complete mechanical harvesting. The Corp. used 23 Toft Crawler mounted CH464 cane harvesters, manufactured by Toft Brothers, Ltd., of Queensland, Australia.

These harvesters are powered by 2 G.M.C. 471 Diesel engines. These engines drive 2 Dinapower units which supply the hydraulic power for the machine, which is all hydraulically operated. These self-propelled machines are single row, combine harvesters.

The cane is topped, picked-up, cut at ground level and chopped into pieces averaging 13" long. The chopped pieces fall on the main conveyor, which feeds the swinging loading boom. There is a 3-blade trash extractor at the place where the main conveyor delivers the chopped cane to the boom. Another extractor is located where the cane falls on the carts or trailers.

Minor changes are being made to correct mechanical difficulties, among them: stronger conveyor chains and sprockets and heavier shaft bearings.

The cutting device did a remarkable job. The pick-up system and chopping devices worked very well, even when harvesting recumbent cane. Harvest of ratoon crops in the fields this year compared favorably with hand cut ratoons.

The machines harvested 1,109,724 tons of cane and supplied the mill with 5,449 tons of cane per grinding day during the past season. The projected grinding rate was not accomplished mainly because of the shortage of transportation equipment. This shortage developed as a result of longer loading time as compared with the continuous loaders previously used.

Because of the shorter pieces of cane, the compaction increased so much that direct loading into highway trailers was used. For direct loading, the height of the trailers was reduced, but the average weight was still about 20 tons per load. This operation allowed the elimination of wagons and transfer stations, so it is planned for the next season to haul the cane only with highway trailers. The average harvesting capacity for the season was 10.2 tons per hour per machine. However, from May 15 through May 20 a field test was conducted at Zone 4 using all the necessary transportation equipment. The harvesting capacity of the machine increased to 20.4 tons of cane per hr.

Despite all difficulties and low cutting rates the costs of cutting and loading per ton of cane were as follows:

Cutting (fuel, lube, operators)	- \$ 0.56
Loading	- 0.15
Depreciation	- 0.17
Repairs and maintenance	- <u>0.25</u>
Total cost	\$ 1.13 per ton of cane

This compares to \$2.29 per ton of hand-cut cane for the 1971-72 season. Despite the difficulties encountered it was concluded that the machines did an excellent job, especially when considering the total shift from hand-cut cane to complete mechanical harvesting.

EFFECTS ON THE FACTORY OPERATION

The first effect of mechanical harvesting was to increase the trash from 5% to an average of 10.90%. The highest average for a 15-day period was 15.33% and the lowest 8.49%. The highest single test was 36.36% and the lowest 4.35%. The highest amounts of trash occurred at the beginning of the season, when the leaves and tops were very green, burning was poor, rainfall was more frequent, the lowest yielding fields were harvested, and the machine operators were inexperienced.

As a result of the trash increase, the fiber % cane went up from an average of 12.30 to 13.34%. The bagasse % cane increased from 29.36 to 32.47%, increasing the bagasse loss from 0.74 to 0.93%. The rolls slippage and the amount of bagacillo increased and the mill extraction decreased.

The increase in the compaction of the cane brought about some difficulties in the cane conveyors. Before the beginning of the grinding season the cane leveler was lowered to control the height of the cane in the main conveyor. During the grinding season the feeding table structure had to be reinforced. Breakdowns were experienced in the motor shaft of the auxiliary conveyor, in a sprocket of the main conveyor tail shaft, and in the pillow block of the main conveyor motor shaft due to excessive loads of cane.

At the boiling house the amount of mud increased. It varied according to the milling rate and cleanness of the cane. It was observed after rains, during foggy nights or when low tonnage or unburnt cane was processed, that the amount of mud in the clarifiers increased sharply.

The amount of mud to be handled increased at the filtering station. There was no appreciable difference in the mud and cake exhaustability, thickness, dryness, etc., compared with muds of hand-cut cane.

As a result of the increase in the amount of mud it was assumed that the clarification and filtration capacity of the factory had decreased by about 20%. For the rest of the factory, nothing different or abnormal was noticed. Massecuite viscosities, graining of syrup or molasses or a mixture of them, size and configuration of sugar crystals were normal. It is safe to say that under the conditions that prevailed for the past season the control of the clarified juice quality will allow other processing operations to be conducted with efficiency.

THE A. DUDA AND SONS MECHANICAL FURROW STALK CHOPPER

Gene Dodgen

ABSTRACT

The A. Duda and Sons mechanical furrow stalk chopper was designed and built by Vernie Boots, of A. Duda and Sons, in the fall of 1972. It was constructed to facilitate the cutting of long cane lying in the furrow into approximately 18-to 20-in. lengths. In addition to cutting the long cane into short lengths, the implement was designed to apply insecticide, cover cane, and pack dirt on top of covered cane. The chopper was used on approximately 2,000 acres of planted cane during the 1972-1973 planting season.

Editor's note: Only the Abstract of this paper was available for the Proceedings.

EVALUATION OF PRE-HARVEST, FOLIAR-APPLIED CHEMICALS
FOR SUCROSE ENHANCEMENT IN FLORIDA SUGARCANE

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ABSTRACT

Several organic chemicals have demonstrated a potential for enhancing sucrose content when applied in the early fall to sugarcane foliage in Florida. Numerous compounds of diverse structure have engendered positive responses apparently associated with retardance of shoot growth and concomitant elaboration of sucrose. The mechanism, or mechanisms, of action of these compounds is not known at this time, but an acceptable sucrose-enhancing chemical for pre-harvest, foliar application must fit several criteria: a consistent annual response; a fairly prompt rise in sucrose levels; a peak response for 4 to 8 weeks; and no harmful effect on cane tonnage nor on the subsequent ratoon crop. The following compounds have been evaluated in on-going trials: Ethrel (Amchem); Cycocel (American Cyanamid); C-8728 (Chemagro); DA-5 and DPX-1840 (du Pont); BNS and GS-23 560 (Geigy); H-17537 (Hercules); CP-41820, CP-41845, MONS-0139, and MONS-1184 (Monsanto); R-191 (Pennsalt); MBR-6033 (3M); 417-H (Thompson-Hayward); Maintain CF-125 (U.S. Borax); and Racuza (Velsicol). CP-41820, and CP-41845 have been the most effective sucrose-enhancing compounds, although several others have appeared promising. Marked sucrose suppression was noted for Maintain CF-125, while MONS-0139 caused severe stubble damage. CP-41845 has induced occasional stubble retardation, although its analog, CP-41820, has appeared innocuous.

TESTING CHEMICAL RIPENERS FOR SUGARCANE IN LOUISIANA^{1/}

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ABSTRACT

Chemical ripeners have been screened under controlled conditions in Louisiana for more than 20 years; to date, more than 90 compounds or formulated products have been tested and discarded because of inconsistent or low activity. Two products screened during 1972 gave significant activity as ripeners. Preliminary results in 1972 indicate that ripening activity is generally confined to the uppermost half of the stalk. Also, chemical ripeners are more apt to give positive results in Louisiana when environmental conditions are not favorable for natural ripening, i.e., when nights are warm and soil moisture is high. However, the combination of relatively rapid-maturing varieties and usually favorable environmental conditions during most harvests, namely cool night temperatures and low rainfall, make the success of any chemical ripener less likely during the short harvest season in Louisiana than during the long harvest seasons in the tropics.

INTRODUCTION

Louisiana sugarcane growers depend largely on natural environmental conditions for maturation (9). A combination of cool temperatures and dry soil during the harvest retard vegetative growth (8) and promote ripening (5). Yates (16, 17, 18) suggested that the superior quality of harvested sugarcane in Queensland was associated with slow growth induced by low temperatures. He indicated that low temperature is more effective than low soil water in promoting sucrose accumulation. Other workers (3, 7) also have noted the importance of low temperatures for ripening.

The average yield of sugar per net ton of cane of naturally matured sugarcane in Louisiana for the period 1967 to 1971 was 9.0% (1); in other words 10.1 metric tons of cane were required to produce one ton of sugar. In contrast, only 7.0 tons of cane are required for each ton of sugar produced in Queensland (18). Louisiana sugarcane is harvested at 8 to 10 months of age, whereas in Queensland the average age of harvested cane is 12 months. A serious handicap for the Louisiana industry is the probability of a killing freeze during the harvest, which requires that the harvest begin with immature cane before the freezing temperatures.

Through plant breeding, commercial varieties of sugarcane have recently been developed which are capable of producing relatively high yields of sugar during the 8-to 10-month growing season. However, to combine high sucrose genetically with the other necessary characteristics of a modern variety, is a difficult task, normally requiring many years of work by many scientists. In lieu of varieties with inherently higher juice quality, an alternate approach would be to use chemical ripeners. This approach is being seriously considered in many tropical areas where weather conditions are unsuitable for natural ripening (13, 14, 15), economics dictate year-round harvesting (13), or the harvesting season extends beyond the period of optimum natural ripening (2, 15, 18).

Coleman and Hebert (4) examined the effects of 11 growth regulators as ripeners from 1951 to 1953 at Houma. They concluded that the failure of all 11 compounds was caused by their adverse effect on one or more of the enzyme systems involved in carbohydrate metabolism. Since 1948, other workers at Houma (unpublished data) have tested 97 chemicals with varying modes of action for activity as ripeners. To date, 11 chemicals have shown some activity as ripeners. The 11 chemicals that have shown some activity are: allyltrimethyl ammonium bromide (AMAB), 6-aminopurine (adenine), TD-248 and TD-319 (composition unknown), methyl caprylate, monopotassium phosphate, GS-241 [N,N-dimethyl-N-

^{1/} This is a report on the current status of research involving use of certain chemicals that require registration under the Federal Environmental Pesticide Control Act (FEPCA). This report does not contain recommendations for the use of such chemicals, nor does it imply that the uses discussed have been registered. All uses of these chemicals must be registered by the appropriate State and Federal agencies before they can be recommended.

(2-hydroxyethyl)-N-octadecylammonium chloride], TD-692 [mono-("coco"dimethylamine)succinate], and Polaris [N,N-bis(phosphonomethyl)glycine]. Only 2 of these 11 compounds are still in the testing program. One product has undergone field testing in Louisiana in 1972 by the manufacturer; the results are not yet available. The other 9 compounds have been dropped from further testing because of inconsistent or low activity.

GENERAL SCREENING

In general, test chemical ripeners are applied to commercially grown cane 7 to 9 months of age in the plant or ratoon crop. Two to 8 replications (1- or 3-row plots either 3.7 or 7.3 m long) are sprayed at several rates using a knapsack sprayer 4 to 8 weeks before harvest. Samples of 10 to 20 stalks are weighed and milled on the day of application and again on 4 or 5 subsequent dates. Crusher juice analyses include brix by hydrometer, apparent sucrose by polarization, and purity as the ratio of sucrose to brix (11). Crusher juice brix and sucrose are used in estimating yield of 96-pol sugar per ton of cane (10). Plots with no chemical additives are sampled on each sampling date as controls. All samples are weighed and an average stalk weight is obtained for each treatment before milling.

Shoot or stand counts are made in the spring after the chemical treatment to investigate possible effects on stubbling ability.

Preliminary data are used first to establish activity of each candidate as a ripener, then to establish optimum rate and time of application before harvest.

ADVANCED SCREENING

When the ripening activity of a compound has been confirmed by at least 2 years of favorable data in the initial screening test, a larger replicated yield test with commercially grown cane 7 to 9 months of age is scheduled to measure yield of sugar per ha and the effect of the chemical ripener on the subsequent stubble crop. Three or 4 replications, each 3 rows wide (5.4 m) by 3.7 or 7.3 m long, for each chemical ripener are sprayed, using a knapsack sprayer at the optimum rate established from the initial test. Checks are left unsprayed as controls. The date of application depends on the activity curve found for the previous test. At harvest, all cane in a plot is cut, topped at the first hard joint, and weighed. This weight is used to calculate gross tons of cane per ha. Trash determinations are made for each treatment, the weight of trash being subtracted from the gross weight to give net cane yields. Samples of 15 stalks are made as previously described. Yield of sugar per ha is estimated by multiplying tons of cane per ha by estimated sugar per ton of cane.

In the subsequent stubble crop, the above procedure is repeated on approximately 9-month-old cane that has not been resprayed with the test ripeners. These data are necessary to test possible deleterious effects of the ripener on the stubble crop.

RESULTS

TD-692 (Armak).

Armak's TD-692 [mono-("coco"dimethylamine)succinate] was initially tested at Houma during 1972. TD-692 is described by the manufacturer as slightly toxic and producing moderate skin and eye irritation. Residue analyses on sugarcane have not been made.

Only small quantities of TD-692 were made available for testing during 1972. A planting of the variety CP 55-30 in the plant-cane crop was divided into 4 3-row plots, each 7.3 m long. TD-692 was applied at 3 rates, 0.3, 0.6, and 1.1 kg active ingredient (a.i.)/ha, on Sept 13, 1972. The fourth plot was left unsprayed, serving as a control. Two randomly selected 10-stalk samples were harvested from each plot on 5 dates, the application date and 3, 5, 7, and 9 weeks later. Maximum activity, as indicated by estimated sugar per ton, was noted about 5 weeks after spray application (Fig. 1). The 1.1 kg a.i./ha rate showed the maximum increase over the control (13.2 kg) in yield of sugar per ton of cane.

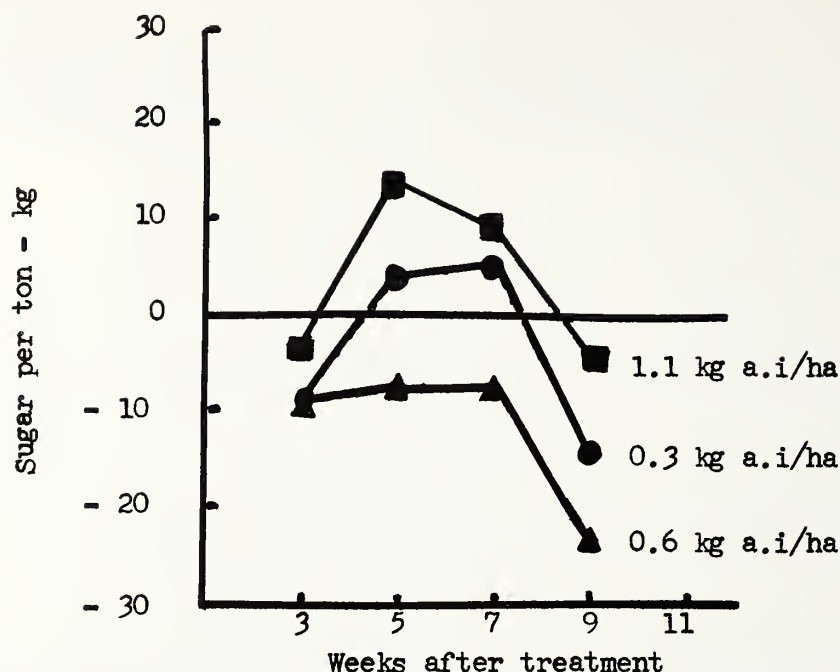


Fig. 1. Effect of TD-692 on calculated yield of sugar per ton in the plant-cane crop, variety CP 55-30, during 1972. Control values for each date set at zero; values of treatments are indicated as above (+) or below (-) control.

No phytotoxicity or apparent changes in growth were noted in any of the treated plots.

Polaris (Monsanto).

Monsanto's Polaris (formerly CP-41845), a substituted amino acid [N,N-bis(phosphonomethyl)glycine], has been tested at Houma for 2 years. Polaris is classified by the manufacturer as practically non-toxic by oral ingestion, but can cause moderate skin and severe eye irritation.

Polaris has been given considerable attention as a chemical ripener on a world-wide basis (12). It has a temporary approval by the Federal Government for treatment of limited acreage in Florida, Hawaii, Louisiana, and Puerto Rico. Data from Hawaii (12, 13) have been positive, with only minor exceptions. The following factors cited from a Hawaiian source (12) give Polaris an excellent chance of becoming the first commercially available chemical ripener: 1) its activity as a ripener; 2) its low mammalian toxicity (LD_{50} for rats of 3,929 mg/kg); 3) its relatively low plant toxicity; 4) its low residue; 5) its high solubility in water; and 6) its immediate commercial production by the manufacturer. However, commercial use depends on registration and subsequent approval by the Federal Government. The material is expensive; only limited areas are likely to be treated.

Polaris was first tested at Houma in 1971. No significant increase in ripening was noted in either of the 2 varieties treated, CP 44-101 and CP 61-37, in the first-stubble crop at 3, 5, 8, and 10 weeks after initial spray application on Sept 10, 1971. Application rates were 1.9 and 3.9 kg a.i./ha. Natural ripening during the 1971 harvest exceeded the previous 5-year average (9). A combination of ideal drying conditions and cool temperatures provided the conditions for exceptional natural ripening. Normally, a chemical ripener that fails to enhance sucrose accumulation in any one year is dropped from further testing. However, because of the excellent natural ripening conditions in 1971 and the position of Polaris as a proven ripener in other sugarcane areas, a second screening test was scheduled for 1972.

Stand counts in the spring of 1972 showed no deleterious effects on stubble behavior at the rates tested. However, it was observed, where 5.8 kg a.i./ha had been applied on about 12 m of a border row, that Polaris caused a serious reduction in shoot population in the subsequent stubble crop.

On Sept 6, 1972, Polaris was applied on the sugarcane variety CP 55-30 in the plant-cane crop at 3 rates, 1.9, 2.8, and 3.9 kg a.i./ha. There were 8 replications, each measuring 3 rows wide by 7.3 m long. Eighteen stalks were cut and topped at the first hard joint from each plot on 5 sampling dates: application day and 4, 6, 8, and 10 weeks later. Nine of the stalks were weighed and milled. The other 9, each about 1.8 m long, were divided into equal segments, the upper 0.9 m and the lower 0.9 m. Each of these subsamples was weighed and then milled. Crusher juice samples were weighed and analyzed as previously described.

Significant increases in crusher juice brix, sucrose, and sugar per ton of cane were noted 4, 8, and 10 weeks after treatment (Table 1), with the greatest activity observed at the 1.9-kg/ha rate. Tendency for purity to increase in the treated plots was nonsignificant. This would indicate that both brix and sucrose were being increased at about the same rate, resulting in approximately the same value for purity in the treated and untreated plots.

Table 1. Effect of Polaris (Monsanto) on crusher juice brix, sucrose, purity, and calculated sugar per ton of sugarcane, variety CP 55-30 in plant cane crop, at Houma, La., during 1972.

Treatment ^{1/}	Dates of sampling				
	Brix				
	Sept 6	Oct 4	Oct 18	Nov 1	Nov 14
Control	10.9	13.3	15.6	15.6	16.1
1.9 kg/ha	10.9	14.3	15.9	17.0	17.2
2.8 kg/ha	10.9	13.5	16.3	16.8	16.7
3.9 kg/ha	10.9	14.2	16.2	17.0	17.1
LSD (0.05)	NS	0.5	NS	0.6	0.8
Sucrose					
Control	6.0	8.8	11.4	12.0	12.6
1.9 kg/ha	6.0	9.8	12.0	13.5	14.0
2.8 kg/ha	6.0	8.9	12.2	13.4	13.2
3.9 kg/ha	6.0	9.6	12.4	13.4	13.7
LSD (0.05)	NS	0.7	NS	0.7	1.0
Purity					
Control	55.2	66.3	73.1	77.4	77.9
1.9 kg/ha	55.2	68.4	75.5	79.0	80.8
2.8 kg/ha	55.2	65.8	75.1	79.8	79.2
3.9 kg/ha	55.2	67.7	76.4	78.9	80.3
LSD (0.05)	NS	NS	NS	NS	NS
Dates of sampling					
Sugar per ton (kg)					
Control	25.5	44.9	62.2	68.0	71.3
1.9 kg/ha	25.5	50.7	66.7	77.0	80.8
2.8 kg/ha	25.5	44.9	68.0	77.0	75.9
3.9 kg/ha	25.5	49.9	69.2	76.6	79.1
LSD (0.05)	NS	4.9	7.0	5.4	7.0

^{1/} Active ingredient (a.i.) per ha.

The stalk fractions showed that the activity of Polaris was confined to the upper half of the stalk (Table 2). Only on one sampling date, 8 weeks after spray treatment, was there significant ripening activity in the lower half of the stalk.

Table 2. Effect of Polaris (Monsanto) on crusher juice sucrose % of segmented stalks (upper half vs lower half) of the variety CP 55-30 in the plant-cane crop at Houma, La., during 1972.

Treatment	Dates of sampling									
	Sept 6		Oct 4		Oct 18		Nov 1		Nov 14	
	U ^{1/}	L ^{1/}	U	L	U	L	U	L	U	L
Control	1.5	9.9	4.9	12.1	8.2	14.5	8.6	14.4	9.9	15.4
1.9 kg/ha	1.5	9.9	6.3	12.6	8.3	14.1	10.4	15.2	11.2	15.8
2.8 kg/ha	1.5	9.9	4.8	12.0	9.2	14.3	10.0	14.9	10.7	15.2
3.9 kg/ha	1.5	9.9	6.3	12.0	9.5	14.3	10.5	15.5	10.6	15.1
LSD (0.05)	NS	NS	1.0	NS	1.1	NS	1.0	0.7	NS	NS

^{1/} U, upper half; L, lower half.

Polaris caused noticeable deterioration of the shoot apex. However, this effect did not interrupt developing internodes elongated before spray treatment. The average weight per stalk did not materially differ between treated and untreated plots on any of the sampling dates. At about 6 to 10 weeks after application of Polaris, development of the upper 4 to 6 axillary buds on most stalks was observed in all treated plots, but especially in those plots receiving 2.8 and 3.9 kg/ha. Necrosis was confined mainly to the shoot apex; there was little leaf toxicity. Leaves showed bleached areas within 10 days of treatment, but effects soon faded.

Shoot counts in the spring of 1973 showed no deleterious effects of Polaris on stubble behavior at the rates tested.

DISCUSSION

Rapid natural ripening and high sucrose levels occurred throughout most of the 1971 sugarcane harvest in Louisiana (9). In 1972 natural maturity was considerably delayed, and sucrose levels were significantly lower than the average for the preceding 5-year period (unpublished data). While nearly ideal environmental conditions existed in 1971 for rapid natural maturity, warm temperatures and excess soil moisture delayed maturity of the 1972 crop. Sugarcane of most varieties continued to grow vegetatively. TD-692 and Polaris showed significant activity as ripeners in 1972.

Samuels et al (14) suggested that the success or failure of chemical ripeners in Puerto Rico may depend on the stage of maturity of the cane. They further indicated that cane with low or decreasing sucrose and purity levels responded to ripening compounds, whereas cane with naturally high or increasing sucrose or purity values failed to respond. In Louisiana the quality of cane during most harvest seasons is increasing rapidly, indicating that the activity of a chemical ripener would be negligible. Hebert and Davidson (6) in 1960 and Legendre (9) in 1972 reported that the average daily gain of sugar per metric ton of cane during most harvest seasons for most commercially grown varieties was 0.5-0.7 kg. Therefore, the harvesting of relatively rapidly maturing varieties and favorable environmental conditions during periods of cool night temperatures and low soil moisture make the success of any chemical ripener less likely in Louisiana. However, if one could predict that environmental conditions would be unsuitable for natural ripening, a chemical ripener would be successful.

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SUCROSE ENHANCEMENT WITH POLARIS IN LOUISIANA SUGARCANE

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ABSTRACT

Six varieties of Louisiana sugarcane were tested with the cane ripener and sucrose enhancer glyphosine (trademarked Polaris, formerly CP 41845) in a total of 14 tests in 1972. These were all single-rate tests applied by aircraft to 2 to 5 acre plots, 5 to 7 weeks prior to the intended harvest. Weekly brix readings, as well as final lab analysis for brix, sucrose, and purity, were made at harvest, and trash and tonnage records were kept. From these tests, there appears no doubt that glyphosine can aid sucrose enhancement in Louisiana sugarcane early in the season. Nine out of 14 tests gave a positive response to glyphosine treatment. These positive responses averaged US \$56.96 per acre for tons of standard cane calculated. Of the 6 varieties tested, L 62-96, L 60-25 and CP 52-68 showed the most favorable response in both lab analysis of cane juice and resultant grower dollars per acre. Weekly brix readings indicated that all varieties tested could have the ripening process hastened by two to 3 weeks when treated with glyphosine.

Editor's note: Only the Abstract of this paper was available for the Proceedings.

FALLOW FLOODING FOR CONTROL OF JOHNSONGRASS IN SUGARCANE:
EFFECT OF BAGASSE APPLICATION AND TIME AND DEPTH OF FLOODING

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ABSTRACT

The general public has become increasingly concerned over the potential pollution hazards which may result from the excessive use of agricultural pesticides. This has generated considerable research effort to determine ways and means of controlling agricultural pests by supplementing chemical control practices, where feasible, with nonchemical techniques. There is evidence that fallow flooding during the intercycle year for sugarcane in Louisiana will effectively destroy johnsongrass rhizomes, and offers the possibility of devitalizing the seeds as well. Moreover, it appears that as a flooded, infested soil becomes progressively anaerobic and chemically reduced, as characterized by a lowering of the redox potential (Eh), the viability of johnsongrass seed decreases accordingly. An experiment was initiated on the La. Agric. Exp. Sta. Ben Hur Farm near Baton Rouge to investigate possible interactions of depth and duration of flooding, and the presence of an organic amendment (bagasse) on the viability of johnsongrass seed. The experimental area consists of a Mhoon-Commerce type soil heavily infested with johnsongrass (>5 million viable seeds per acre 2 1/2 in. depth). Adjacent levees were constructed to form 3 50x100-ft impoundments with a uniform lengthwise slope of 0.1%. Bagasse was applied at a rate of 10 tons per acre to 3 50x50 ft-plots located at the upper, middle, and lower parts of each impoundment, which after flooding corresponded to water depths of 5, 10, and 15 in. respectively. Bagasse was incorporated uniformly to a 6-in. soil depth and the impoundments were sequentially flooded in Jan., Mar., and May, 1972. After continuous flooding for periods of 7, 5, and 3 months, respectively, the impoundments were drained in Aug. and planted to sugarcane in early October 1972. Observations made during the fall post-flooding period (Aug. to Oct. 1972) showed a substantial reduction in johnsongrass seed populations in all 3 impoundments due to flooding. There was a progressive decrease in seed populations as the duration of flooding increased. For example, the total cumulative population of seed that germinated and emerged on those plots subject to a 5-in. flooding depth without bagasse, and after 3 tillage operations, were 3.1 million, 2.1 million, and 162 thousand per acre for flooding periods of 3, 5, and 7 months, respectively. Where bagasse had been applied, the corresponding values were 870, 263, and 20 thousand per acre, respectively. Johnsongrass seed populations on plots flooded to 10- and 15-in. depth were also decreased though to a considerably lesser extent compared with the 5-in. flooding depth. While this may seem somewhat paradoxical, a possible explanation is that the higher temperatures which prevailed in the shallow-flooded plots contributed to a higher level of microbial activity which in turn caused a greater depression in the redox potential. This reasoning was substantiated by Eh measurements which revealed that intense reducing conditions of about -250 mv occurred within a 4-in. soil depth on the shallow-flooded plots compared with values of +100 mv on the deep-flooded plots. Redox potentials were lowest where bagasse had been incorporated. Assessment of johnsongrass seed populations will continue through the 1973 growing season after which sugarcane yields will be evaluated.

THE USE OF CHEMICAL HERBICIDES TO CONTROL RHIZOME JOHNSONGRASS
IN LOUISIANA SUGARCANE

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Baton Rouge, Louisiana

ABSTRACT

Asulox appears to be a very good chemical to control johnsongrass in sugarcane in Louisiana. Rates of 4 to 5 pints combined with silvex at 1 lb per acre controls over 90% of the johnsongrass that is growing and has reached the flagging stage of maturity when applied. Applications made early in the season may show some regrowth of johnsongrass. Early applications of TCA and dalapon or low rates of dalapon applied when the johnsongrass is approximately 8 to 10 inches high followed with Asulox and silvex gives the best control of johnsongrass without injury to sugarcane. Two applications of Asulox at 4 to 5 pints per acre (broadcast) also gives excellent control of johnsongrass without injury to the sugarcane but may not be economically feasible to use. More work on rates per acre, combinations of dalapon and Asulox is being continued.

There have been many changes made in the overall agronomic practices of cultivation, fertilization, weed control and others in the past 20 years in Louisiana sugarcane. In some cases one practice has led to major changes in other fields. A good manager today adapts these changes into his routine schedule to take advantage of his own environmental conditions.

Winter weeds and grasses growing in plant sugarcane the first fall and winter after the cane is planted can affect yeild of the plant cane crop and also reduce yields in the stubble crop by reducing the population of sugarcane in all years of growth. Without a good stand of plant cane it is almost impossible to make normal or above normal yields in the stubble crops to follow.

The fallow plow program that was started in 1947-48 is still a good agronomic cultural practice that not only controls a high percentage of johnsongrass but also leaves the soil in good condition for sugarcane production.

Plowing the land to be planted to sugarcane 6 to 8 times during the spring and summer before the cane is planted kills a high percentage of the johnsongrass rhizomes. The program also causes many grass and weed seeds to germinate and to be killed in the spring and summer. No chemical has been found that is as effective as fallow plowing regardless of cost involved for its application.

The preemergence chemicals that are now in the market will do a very good job in controlling weeds and grasses in plant sugarcane if they are used as suggested by the Cooperative Extension Service. In areas where there are high populations of seed in the soil some johnsongrass seedlings may escape the preemergence chemicals and produce rhizome plants. These plants become a real problem in the stubble crops for the following years of production.

The infestation of johnsongrass from rhizomes varies from one block of stubble sugarcane to the adjoining block. An area that might be considered heavily infested will vary in ground coverage from 40 to 100%. This makes evaluation of a new chemical herbicide difficult, especially in determining rates per acre and the time of application.

There have been a large number of chemicals in screening tests for johnsongrass rhizome control since 1948. Only two, TCA and dalapon, have given some control but have not been more than 70% effective when properly applied. Some injury from the application of dalapon has occurred, especially on some varieties.

In 1969, a new chemical, the sodium salt of methyl sulfanilylcarbamate, asulam or Asulox, was tested and showed promise in controlling johnsongrass growing from rhizomes. The use rate for controlling johnsongrass is not injurious to the sugarcane.

Asulox is effective in killing most broadleaf grasses but has little or no effect on the fine or narrow leafed grasses. This chemical is very slow in action, and in most cases 3 to 4 weeks are required to observe visual knockdown of the johnsongrass. The material was given an experimental label in 1972 and it is expected to obtain a full label for use in 1973.

The results obtained with the material in 1973 have been very good. Some was applied with ground sprayers while some was applied with an airplane.

Data collected on yield results of stubble sugarcane treated with different rates of Asulox are shown in Tables 1 through 6. Tables 1, 2, and 3 show the yield of sugarcane in tons per acre (Table 1), pounds of sugar per ton (Table 2), and pounds of sugar per acre (Table 3) when the herbicide was applied with ground sprayer. Tables 4, 5, and 6 show the yield of sugarcane in tons per acre (Table 4), pounds of sugar per ton (Table 5), and pounds of sugar per acre (Table 6) when Asulox applied with an airplane.

Table 1. Yield of stubble sugarcane in tons per acre when treated with Asulox for johnsongrass control. Applied with a ground sprayer 1970-1972.

Year	Variety	Check	Plantation practice	One-half ^{2/} gal plus	One gal plus 1 lb	1/2 plus 1/2 gal plus	1 gal plus 1 gal plus
				1 lb silvex	silvex	1 lb silvex	1 lb silvex
1970	CP 55-30	29.6 ^{1/}	39.1	37.8	40.6		
1970	CP 55-30	16.0	30.5	30.5	33.2		
1971	L 62-96	23.4	20.8		26.3	25.0	23.8
1972	CP 48-103	7.4	19.8			32.1	33.4
1972	CP 48-103	<u>14.4</u>	<u>22.4</u>	<u>25.5</u>	<u>30.9</u>	<u>21.7</u>	
Average 4 tests		20.9	28.2		32.8		
Average 3 tests		20.0	30.7	31.3	34.9		
Average 3 tests		15.1	21.0			25.7	
Average 2 tests		18.9	21.6		28.6	22.6	
Average 2 tests		15.4	20.3			27.8	28.6
Average 1 test		23.4	20.8		26.3	23.4	23.8
Average 1 test		14.4	22.4	25.5		21.7	

^{1/} Tons of clean sugarcane per acre - Average of 4 replications each test.

^{2/} Asulox based on 3.34 lb per gal.

Table 2. Yield of stubble sugarcane in pounds of sugar per ton when treated with Asulox for johnsongrass control. Applied with a ground sprayer 1970-1972.

Year	Variety	Check	Plantation practice	One-half ^{1/} gal plus	One gal plus 1 lb	1/2 plus 1/2 gal plus	1 gal plus 1 gal plus
				1 lb silvex	silvex	1 lb silvex	1 lb silvex
1970	CP 55-30	148.3 ^{2/}	139.9	146.9	148.3		
1970	CP 55-30	170.8	133.7	159.9	153.2		
1971	L 62-96	228.7	211.4		223.4	229.5	225.3
1972	CP 48-103	194.0	189.9			175.2	190.7
1972	CP 48-103	<u>185.1</u>	<u>172.9</u>	<u>179.0</u>	<u>195.0</u>	<u>180.2</u>	
Average 4 tests		174.6	159.1		124.2		
Average 3 tests		167.8	148.8	161.6	165.5		
Average 2 tests		206.9	192.1		209.2	204.8	
Average 2 tests		211.4	200.6			202.3	208.0
Average 1 test		228.7	211.4		223.4	229.5	225.3
Average 1 test		185.1	172.9	179.0		180.2	

^{1/} Asulox based on 3.34 lb per gal - Average 4 replications each test.

^{2/} Normal juice sucrose.

Table 3. Yield of stubble sugarcane in pounds of sugar per acre when treated with Asulox for johnson-grass control. Applied with a ground sprayer 1970-1972.

Year	Variety	Check	Plantation practice	One-half ^{1/} gal plus 1 lb silvex	One gal plus 1 lb silvex	1/2 plus 1/2 gal plus 1 lb silvex	1 gal plus 1 lb silvex
1970	CP 55-30	4389 ^{2/}	5470	5553	6020		
1970	CP 55-30	2113	4078	4877	5086		
1971	L 62-96	5353	4400		5875	5743	5457
1972	CP 48-103	1436	3760			5624	6369
1972	CP 48-103	<u>2665</u>	<u>3873</u>	<u>4565</u>	<u>6026</u>	<u>3910</u>	
Average 4 tests		3630	4455		5752		
Average 3 tests		3056	4474	4998	5711		
Average 2 tests		4009	4137		5951	4827	
Average 2 tests		3395	4080		5951	5684	5913
Average 1 test		1436	3760			5624	6369
Average 1 test		2665	3873	4565		3910	

^{1/} Asulox based on 3.34 lb per gal - Average 4 replications each test.

^{2/} Based on normal juice sucrose.

Table 4. Yield of stubble sugarcane in tons per acre when treated with Asulox applied by airplane on three locations - 1970-1972.

Year	Location	Variety	Check	Plantation practice	Treatment and rate per acre		
					1 gal alone ^{2/}	1 gal plus 1 lb silvex	1/2 gal plus 1 lb silvex
1970	Lula	CP 48-103	25.5 ^{1/}	33.7	44.7	48.7	
1972	Westfield	CP 48-103	6.4	22.3		24.0	24.7
1972	St. Emma	CP 61-37	<u>7.0</u>	<u>22.8</u>		<u>25.5</u>	<u>29.6</u>
Average 3 tests			13.0	26.3		32.7	
Average 2 tests			6.7	22.6		24.8	27.2

^{1/} Tons of clean cane per acre - Average of 4 replications each test.

^{2/} Asulox based on 3.34 lb per gal.

Table 5. Yield of stubble sugarcane in pounds of sugar per ton when treated with Asulox applied by airplane on three locations - 1970-1972.

Year	Location	Variety	Check	Plantation practice	Treatment and rate per acre		
					1 gal alone ^{2/}	1 gal plus 1 lb silvex	1/2 gal plus 1 lb silvex
1970	Lula	CP 48-103	190.7 ^{1/}	176.2	155.5	140.1	
1972	Westfield	CP 48-103	205.7	208.0		208.4	203.8
1972	St. Emma	CP 61-37	<u>180.7</u>	<u>14.18</u>		<u>174.4</u>	<u>166.5</u>
Average 3 tests			192.4	175.3		174.3	
Average 2 tests			193.2	174.9		191.4	185.2

^{1/} Normal juice sucrose - Average of 4 replications each test.

^{2/} Asulox based on 3.34 lb per gal.

Table 6. Yield of stubble sugarcane in pounds of sugar per acre when treated with Asulox applied by airplane on three locations -- 1970-72.

Year	Location	Variety	Check	Plantation practice	Treatment and rate per acre		
					1 gal alone ^{1/}	1 gal plus 1 lb silvex	1/2 gal plus 1 lb silvex
1970	Lula	CP 48-103	4863 ^{2/}	5938	6951	6823	
1972	Westfield	CP 48-103	1327	4649		4931	5013
1972	St. Emma	CP 61-37	<u>1291</u>	<u>3212</u>		<u>4439</u>	<u>4907</u>
Average 3 tests			2494	4600		5398	
Average 2 tests			1314	3931		4435	4960

^{1/} Asulox based on 3.34 lb per gal - Average of 4 replications each test.

^{2/} Sugar per acre on normal juice sucrose.

PRODUCTION OF TRUE SEEDS FROM BASIC LINES OF SACCHARUM
AND RELATED GENERA IN NEW CROSSES AT HOUMA, LOUISIANA

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ABSTRACT

Sugarcane crosses involving basic lines of Saccharum and related genera were made during 1972 in the new American Sugar Cane League breeding facility at the U.S. Sugarcane Field Station at Houma, Louisiana. These were the first sugarcane crosses ever made at Houma. The new breeding program is designed to meet the long-range varietal needs of the mainland sugarcane industry. As genetic stocks from new lines approach commercial standards, they are assimilated into crosses with immediate commercial potential by sugarcane breeders at Canal Point, Florida and Baton Rouge, Louisiana. Characteristics being sought from the new breeding materials are resistance to the different strains of mosaic, resistance to the sugarcane borer, cold-tolerance, greater erectness for adaptability to machine harvest, and higher cane tonnage in more ratoon crops. These characteristics have been identified in clones of S. spontaneum, S. robustum, and related genera that hybridize with sugarcane. During the 1972 breeding season at Houma, more than 175,000 viable seeds were produced from crosses involving new germplasm and selected inter-specific hybrids from conventional breeding lines.

INTRODUCTION

A specialized program to breed superior genetic stocks for sugarcane variety improvement was begun during 1972 at the U.S. Sugarcane Field Station at Houma, Louisiana. The first true hybrid seeds of sugarcane ever produced at Houma came from crosses made in the new sugarcane-breeding greenhouse. Construction of the new greenhouse was made possible by a grant from the American Sugar Cane League.

The new program is designed to meet the anticipated long-range varietal needs of the mainland sugarcane industry. Its primary objective is to explore the breeding potential of basic clones of the genus Saccharum and clones of other genera that hybridize with sugarcane.

Older, established breeding programs in Hawaii, Puerto Rico, Florida, and Louisiana concentrate mainly on crosses of genetic lines capable of producing sugarcane varieties of immediate commercial value. The sole purpose of the new program at Houma is to develop new breeding lines to supplement and strengthen the conventional commercial breeding lines.

NEW BREEDING FACILITIES

Greenhouse.

The new sugarcane-breeding greenhouse is 31 ft tall, 62 ft long, and 32 ft wide. The super-structure is entirely of aluminum covered with glass and is constructed to withstand winds up to 200 miles/hr. The facility is equipped with a rapid-recovery hot-water heating system and automatic temperature-control devices to regulate the boiler and to open and close ventilators. Three automatic flat-bed, metal rail carts (16 X 16 ft) are used to move can-cultured breeding canes in and out of the house for controlled treatment of breeding material. A large overhead door (20 X 24 ft), through which the carts pass, is opened and closed electronically. In the greenhouse are 18 crossing cubicles and 36 seed-maturation racks; all are built of lightweight aluminum and construction steel for strength and durability. Concrete water troughs (3 ft wide and 1 ft deep) will soon be built; these will extend the length of the greenhouse on both sides, and will be connected together with 6 in. plastic pipe. Small pumps will be installed within the troughs to circulate, aerate, and freshen the water containing the airlayered flowering stalks set in crosses. At the rear of the greenhouse is a headhouse (12 X 32 ft) containing the boiler, office space, seed dryer, and storage area for tools and equipment.

Photoperiod houses.

Four photoperiod houses (under construction) will be used to control daylength to induce flowering in difficult-flowering varieties and to synchronize the flowering of new genetic stocks and other breeding canes that normally do not flower simultaneously. Each house will contain a motor-driven metal cart with a capacity for 30 10-gal can cultures of selected breeding stocks.

CHOICE AND PREPARATION OF PARENT MATERIAL

Choice of parent varieties for 1972 crosses was based on their potential to develop new lines with disease resistance, borer resistance, cold-tolerance, erectness, vigor, early high sucrose, and other desired characteristics. The new choice was based on data accumulated in screening new genetic lines over

a period of 7 years at Houma, and on specific recommendations of the agronomists, entomologists, plant pathologist, and plant physiologist. Stocks considered most desirable as non-recurrent parents were 5 S. spontaneum clones, 2 F₁ clones of S. spontaneum Pasoeroean, 1 F₁ clone of S. robustum NG (New Guinea) 57-208, 2 F₁ and 2 BC₂ clones of a hybrid cross between genera related to sugarcane (Sclerostachya X Erianthus), and 9 BC₂ clones of S. spontaneum US 56-15-8. Chosen as recurrent parents were 14 commercial breeding canes, including 10 CP (Canal Point, Florida) clones, 3 L (Baton Rouge, Louisiana) clones, and 1 foreign import NCo 310).

Preparation of breeding material used in the crosses began a year in advance. Single-eye pieces of the recommended breeding stocks were planted upright in flats of soil in the fall, in advance of freezing weather. These were overwintered in a seedling greenhouse, and the well-established plants were transplanted to 10- and 15-gal galvanized ashcans in early spring. The can cultures were placed on the carts of the breeding facility and on outdoor racks. They were watered, fertilized, and treated for control of insects as needed. During the growing season, the stools of cane were tied upright to supporting racks. When ready to use in crosses, the individually airlayered stalks were straight and easy to manage.

CROSSING AND SEED PRODUCTION

The new crossing program was successful in its first year, considering the unfinished facilities and the small number of can-cultured breeding canes available. Profuse arrowing occurred in nearly all canes. Ninety-five bi-parental crosses were attempted, and 89 were successfully completed and harvested (Table 1). As shown in the table, S. spontaneum lines were emphasized in the crosses.

Table 1. 1972 basic sugarcane crosses and true-seed production, with reference to new line and generation.

Basic parent	Classification	Generation	No. of crosses	Estimated no. viable seeds
NG 57-208	<u>S. robustum</u>	BC ₁	11	19,576
Pasoeroean	<u>S. spontaneum</u>	BC ₂	2	1,300
SES 6	<u>S. spontaneum</u>	F ₁	3	9,116
SES 147 B	<u>S. spontaneum</u>	F ₁	3	13,692
SES 577	<u>S. spontaneum</u>	F ₁	2	4,832
US 56-15-2	<u>S. spontaneum</u>	F ₁	3	10,088
US 56-15-8	<u>S. spontaneum</u>	F ₁	3	7,654
US 56-15-8	<u>S. spontaneum</u>	BC ₁	6	3,970
US 56-15-8	<u>S. spontaneum</u>	BC ₃	36	81,496
US 67-27-2	<u>Scler.</u> x <u>Erianth.</u>	BC ₁	4	4,860
US 67-33-7	<u>Scler.</u> x <u>Erianth.</u>	BC ₂	4	5,372
Other ^{1/}	-	-	12	13,974
Total	-	-	89	175,930

^{1/} Intercrosses between clones of different generations within and between lines; also inter-generic line crosses.

The first cross of the season was made on Nov. 20, 1972, and the last on Jan. 2, 1973. Crosses were harvested between Dec. 22, 1972 and Feb. 2, 1973. Germination tests indicated that about 175,930 viable seeds were produced. Sixty-four crosses were planted en masse in the seedling greenhouse, and an estimated 109,000 seedlings were germinated. Seed from 25 crosses were stored in the deep-freeze for future evaluation.

DISCUSSION

Selected clones of S. spontaneum, a wild species, are being used to breed for greater resistance to mosaic, ratoon-stunting disease, and borers; more cold-tolerance; increased stalk population, and more and better ratoon crops. Clones of S. spontaneum are also being used to breed for rapid cool-weather growth in early spring, as a deterrent to competition from weeds and grass and to facilitate early layby. New clones from S. robustum lines are being used to develop breeding stocks with improved characteristics for erectness and large-diameter stalks that easily shed their leaves. Derivatives of a Sclerostachya X Erianthus hybrid are also being used to breed for improved tillering and erectness. No crosses involving forms of S. officinarum have yet been made; however, in 1973, attempts will be made to use S. officinarum clones D 74 and Fiji 40 to breed for lower fiber and self-detrashing, larger-diameter stalks. Also, new genes for greater sugar-producing capacity may possibly be obtained from unexplored forms of the S. officinarum genotype.

A wide spectrum of carefully selected germplasm has been planted in can culture for use during the 1973 sugarcane-breeding season. The gene pool is being enlarged to create the degree of genetic diversity required to meet future varietal needs of the Louisiana sugar industry.

A NEW METHOD OF SYNCHRONIZATION OF FLOWERING IN SUGARCANE

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ABSTRACT

The need for broadening the genetic base of the sugarcane breeding program led to the development of methods of flower induction of commercial hybrids, which make possible the crossing of early and late flowering varieties and also the crossing of these varieties with early flowering wild species of Saccharum. This synchronization in flowering was achieved by speeding up the flowering of the commercial varieties. Twelve varieties of sugarcane, with a wide assortment of economic characteristics, were grown in the greenhouse as stubble sprouts in 10-gallon galvanized cans. The best developed tillers of these varieties were marcotted the first week of March. After rooting at the end of March, they were transplanted into stovepipe tubes filled with a mixture of soil, sand and peat moss. In April, the rooted plants were taken out of the greenhouse and placed on carts which could be rolled in and out of photo-period houses. Flower inductive treatments were given from April 10 through June 9; then noninductive short-day treatments were given from June 10 through July 20 or longer. Definite flowering signs were developed by all 12 varieties from the end of June through the middle of July. Flower emergence was spread from July 1 through August 31. Most of the early flowering wild Saccharums form flowers naturally during that period, making it possible to cross them with the best commercial sugarcane varieties.

INTRODUCTION

Synchronization of flowering has been a problem since the beginning of sugarcane breeding. The natural flowering sequence of sugarcane varieties in tropical and some subtropical areas does not allow a wide assortment of crosses. Early-flowering varieties often terminate their flowering before the late-flowering varieties begin. Crossing between these 2 groups of varieties is very difficult. Much more difficult is crosses involving different species of Saccharum and related genera for which the time of flowering differs by 1 to 5 months. An important reason for the narrow genetic base of present day sugarcane varieties is the lack of synchronization in flowering of these varieties and the wild species of Saccharum, making first crosses very difficult.

In the 1920's and 1930's, when there was little information concerning control of flowering, investigators resorted to various techniques in order to make first crosses. In order to make first generation crosses at the Java Sugar Experiment Station in the 1920's, Bremer, as reported by Daniels (3), topped the stalks of S. spontaneum some time before flowering in November and December. This caused sprouting of the lateral buds, and eventually small tassels developed on these sprouts and flowering occurred at the same time of blooming of sugarcane. In the 1930's Brandes (1) crossed a cold resistant S. spontaneum from Turkestan with S. officinarum - S. spontaneum hybrids at Palmira, Colombia, by making interhemispheric shipments of pollen or tassels. Difficulties in controlling the dates of flowering in sugarcane and making first crosses were greatly diminished. In the late fifties the photo-periodic control of flowering of sugarcane became known (2).

With present day information about the control of flowering in sugarcane, the problem of synchronization of flowering can be approached by 3 methods: (1) by controlling the dates of flowering of the wild species, (2) by controlling the flowering of S. officinarum - S. spontaneum hybrids and (3) by controlling the flowering dates of both at the same time.

S. spontaneum flowers 1 to 5 months earlier than S. officinarum - S. spontaneum hybrids. Most sugarcane workers are making interspecific crosses by delaying flowering of the wild species. In Fiji (2, 4), the flowering of S. spontaneum was first induced photoperiodically in many different clones, then delayed by noninductive treatments to coincide with the flowering of S. officinarum and the commercial varieties. In Mauritius (6), the flowering of 2 clones of S. spontaneum was delayed by dark-period interruptions and by day-length extensions during the period of flower development. In Hawaii and Florida (5, 7) the flowering of Saccharum species hybrids was delayed by noninductive photoperiod treatment to make the dates of flowering of these hybrids and the dates of flowering of S. officinarum and commercial varieties coincide.

In this paper, as in an earlier one (8), the results are given of an approach to the problem of synchronization of flowering in sugarcane by speeding up the date of flowering of commercial hybrids instead of delaying the flowering of S. spontaneum. It is more economical to induce the flowering of the commercial varieties and speed up their emergence than to delay naturally flowering S. spontaneum by additional light installations.

MATERIALS AND METHODS

Twelve varieties of sugarcane were used in the synchronization study. These included: CP 44-155, CP 52-1, CP 52-15, CP 52-68, CP 61-37, CP 64-388, CP 65-357, CP 66-346, L 60-25, L 61-67, L 62-96 and L 65-69. Five commercial varieties included in this list were planted on about 85% of the sugarcane acreage in Louisiana in 1972.

Two experiments were conducted with these varieties. The first experiment was to determine the approximate date of flowering of each variety under normal photoperiodic inductive treatments. Single eye cuttings of each variety were planted in the greenhouse in November 1971 in 12 in. clay pots filled with a mixture of soil, peat moss and sand. The plants were thinned to 3 in each pot and allowed to grow in the pots until the middle of February. When the plants had developed 1 to 2 exposed internodes they were transplanted to 10-gal galvanized cans filled with a mixture of soil, peat moss and sand. At the end of April the plants were about 6 ft tall and had about 6 to 8 exposed internodes. They were taken out of the greenhouse to adapt them to the colder outside conditions. On May 20, 1972 the plants were placed on carts for rolling in and out of the photoperiod houses, following a carefully prepared schedule. The photoperiodic treatment given was 12 hr 30 min from May 20 through September 15, 1972. From September 15 through September 27 the photoperiod treatment was 12 hr. After September 27 the plants were exposed to the natural photoperiod until the flowering was completed.

Periodic examinations for signs of flowering were made 60-80 days from the beginning of the treatment. The dates were recorded of definite signs of flowering and of the first flower emergence.

The second experiment was conducted to determine whether the same varieties would flower earlier than in the first experiment by different treatments. The varieties were grown in the greenhouse in 10-gal galvanized cans as stubble cane after the stalks were cut at the end of the 1971 breeding season. The best stalks were marcotted in the first week of March 1972 by wrapping 2 joints of each in a polyethylene bag filled with a wet mixture of soil and peat moss. After rooting at the end of March, the stalks were cut and planted in stovepipe tubes filled with a mixture of soil, sand and peat moss. On April 10, 1972 the sugarcane varieties were taken out of the greenhouse and placed on carts for rolling in and out of the photoperiod houses, following a carefully prepared schedule. A flower inductive photoperiod treatment of 12 hr and 30 min was given from April 10 through June 9, 1972. Then, a non-inductive short-day treatment of 11 hr and 40 min was given the varieties from June 10 through July 31, 1972. Periodic examinations were made for signs of flowering from the end of June through the end of August. Dates were recorded of definite signs of flowering and of first flower emergence for each variety.

Since the purpose of this experiment was to hasten the dates of flowering of the sugarcane varieties, this hastening was expressed as a difference in days between the dates of flowering of each variety by the regular and hastening treatment. The dates were also recorded of flowering of some S. spontaneum forms and of some F₁ hybrids to commercial varieties.

EXPERIMENTAL RESULTS

In Table 1 the dates when each variety showed signs of flowering (elongation) and of emergence of first flowers are given. The earliest varieties required 71 days before the first signs of flowering (end of July) and 108-113 days for emergence of their first flower (September 5-10). On the other hand, the later flowering varieties required 80-90 days before the first signs of flowering (August 8-18) and 138-148 days for emergence of their first flower (September 25-October 15).

Table 1. Dates of visible flower signs and of first flower emergence for 12 sugarcane varieties following inductive photoperiod treatments.

Variety	Date of visible flower signs	Date of first flower emergence	No. days to first emergence
CP 44-155	Aug. 8	Sept. 30	133
CP 52-1	Aug. 8	Sept. 26	129
CP 52-15	July 30	Sept. 10	113
CP 52-68	Aug. 8	Sept. 25	128
CP 61-37	Aug. 18	Oct. 10	143
CP 64-388	Aug. 18	Oct. 5	138
CP 65-357	Aug. 18	Oct. 10	143
CP 66-346	Aug. 18	Oct. 15	148
L 60-25	Aug. 8	Sept. 25	128
L 61-67	July 30	Sept. 5	108
L 62-96	Aug. 13	Oct. 4	137
L 65-69	Aug. 18	Oct. 10	143

The dates of the visible signs of flowering and of the first flower emergence for each of 12 varieties treated by inductive and noninductive treatments are given in Table 2. The early flowering varieties showed signs of flowering between June 18 and June 25 and first flower emergence on July 1 through August 5. The later flowering varieties showed visible signs of flowering between July 2 and July 22 and first flower emergence on the 23rd to 31st of August.

Table 2. Dates of visible flower signs and of first flower emergence for 12 sugarcane varieties following a combination of inductive and noninductive treatments.

Variety	No. of inductive phot. treatments (days) ^{1/}	No. of non-inductive short days	Date of visible flower signs	Date of first flower emergence
CP 44-155	84	50 or more	June 20	Aug. 8
CP 52-1	"	" "	June 19	July 29
CP 52-15	"	" "	June 21	July 3
CP 52-68	"	" "	June 25	July 20
CP 61-37	"	" "	July 2	Aug. 23
CP 64-388	"	" "	July 10	Aug. 25
CP 65-357	"	" "	July 5	Aug. 31
CP 66-346	"	" "	July 4	Aug. 19
L 60-25	"	" "	June 18	July 1
L 61-67	"	" "	June 17	Aug. 5
L 62-96	"	" "	July 14	Aug. 28
L 65-69	"	" "	July 22	Aug. 30

^{1/} Inductive photoperiod treatments include 24 days of natural photoperiod from March 16 through April 9 and 60 days of controlled photoperiod from April 10 through June 9, 1972.

By comparing the dates of flower emergence of the sugarcane varieties treated by the regular photoperiod treatment and the hastening photoperiod treatment, we can calculate the number of days the flowering was advanced by the application of the inductive and noninductive treatment. The results are shown in Table 3. The dates of flowering were speeded up from 31 to 87 days with an average of 52.5 days.

Table 3. Effect of photoperiod treatments on time of flowering in 12 varieties of sugarcane.

Variety	Dates of first emergence		No. of days flowering hastened from normal
	Regular photoperiod treatment ^{1/}	Hastening photoperiod treatment ^{2/}	
CP 44-155	Sept. 30	Aug. 8	53
CP 52-1	Sept. 26	July 29	59
CP 52-15	Sept. 10	July 3	69
CP 52-68	Sept. 25	July 20	67
CP 61-37	Oct. 10	Aug. 23	48
CP 64-388	Oct. 5	Aug. 25	41
CP 65-357	Oct. 10	Aug. 31	40
CP 66-346	Oct. 15	Aug. 19	57
L 60-25	Sept. 25	July 1	87
L 61-67	Sept. 5	Aug. 5	31
L 62-96	Oct. 4	Aug. 28	37
L 65-69	Oct. 10	Aug. 30	41

^{1/} Regular photoperiod treatment includes 130 inductive cycles.

^{2/} Hastening photoperiod treatment includes 84 inductive and 50 or more noninductive cycles.

The approximate dates of flower emergence of some forms of S. spontaneum and the dates of flowering of 4 F₁ hybrids of S. spontaneum clone US 56-15-8 are given in Table 4. Although the data in this table may not be representative of the numerous and more variable forms of S. spontaneum, they show that the approximate dates of flowering are spread from June through November.

Table 4. Dates of flowering S. spontaneum forms and F₁ progenies from crosses with commercial canes.

Clone	Description	Dates of flowering
Tainan	<u>S. spontaneum</u>	End of September
US 56-15-8	" "	1-15 of November
US 60-4-6	" "	10-20 of June
US 61-2-1	" "	10-20 of August
US 66-56-4	F ₁ clones	1-20 of September
US 66-56-7	" "	20-30 of September
US 66-56-9	" "	15-30 of September
US 66-56-15	" "	2-8 of September

DISCUSSION

The flowering of sugarcane is the culmination of physiological processes that take place in the leaves and result in the production of a stimulus which is transferred from the leaves to the growing point, converting it to a flower primordium. After flower initiation, similar processes in the leaves result in the development, organization and elongation of the flower primordium to an inflorescence, which after further development emerges from the leaf sheath. The whole process of sugarcane flowering is photoperiodically controlled, requiring a long period of time. Under our environmental conditions the length of time required from the beginning of the photoperiodic treatment to flower emergence varies from 100-170 days, depending on the variety, the temperature, and probably on other factors.

The date of the beginning of the photoperiodic treatment in the first experiment was scheduled in a way that the flowering could occur in September and October. At that time the bulk of sugarcane crosses are made. The photoperiodic treatment was scheduled about 2 months earlier in the second experiment. If the photoperiodic treatments were the same in both experiments, the time of flower emergence of the varieties in the second experiment would be expected about 2 months earlier than the time of flowering of the varieties in the first experiment. This would be in the middle of the summer, when the flowering of some early flowering forms of S. spontaneum occurs. However, the treatments were different and planned to result in flower emergence in a shorter period of time than the time required for flower emergence in the first experiment.

Eighty-four inductive days were more than enough for flower initiation, and 50 or more short days were more than enough to accelerate flower development and result in a fast flower emergence. The results indicate the opposite. There is a delay in the appearance of the visible signs of flowering between 22-39 days in the early and late flowering varieties in the second experiment, as compared to the time of appearance of the visible signs of the same varieties in the first experiment. From the date of the appearance of the visible signs to the date of the first flower emergence there is no further delay, but a 7 day hastening.

There is a 12 day delay on the average in the time required for first flower emergence of the varieties in the second experiment than that required for flower emergence of the same varieties in the first experiment. This delay of flowering, which is caused by the delay of the appearance of the signs of flowering, could be the result of low temperature during March, April and May rather than the differential photoperiod treatments.

Since the flowering of the sugarcane varieties in the second experiment was advanced by about 50 days it is possible to make crosses between these varieties and some clones of S. spontaneum which flower naturally in the summer under our conditions.

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SELECTION OF HIGH SUCROSE EXPERIMENTAL CLONES FROM SINGLE STOOL BRIX DATA^{1/}

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ABSTRACT

An experiment was conducted with one of its objectives to determine the effectiveness of selection for high brix in the single stool stage in obtaining high sucrose experimental clones. Four crosses in which the parents differed in sucrose level were selected. In 1970 a total of 100 single stools from each cross was chosen at random and the hand refractometer brix of each single stool was determined. Each of the 400 single stools, along with 6 replications of each of the 8 parents, was planted in 10-ft clonal plots. In 1971 each clonal plot was harvested once while in 1972 each clonal plot was harvested at an early date and again at a later date. The sucrose percentage for each of the clones was determined for each harvest. In determining the effectiveness of selection, the association between brix in single stools and the mean sucrose of the clones in the 2 stubble harvests was studied by calculation of correlation coefficients. The coefficients were .52, .54, .63 and .59 for the 4 crosses. These 4 values are highly significant, indicate a moderate degree of association and can be considered as showing a tendency for high brix single stools to produce high sucrose experimental clones. One can conclude that selection for high brix among single stools as a step in obtaining high sucrose clones would have been moderately, but not highly, effective. However, the degree of the association in the clonal stage between sucrose percent in any 2 harvests of the clones also was not high. The correlation coefficients between sucrose in the early harvest and in the late harvest in 1972 were .71, .65, .69 and .59 for the 4 crosses. These associations are highly significant but at best are only moderately strong, showing that not all clones were consistent in relative sucrose content determined at 2 harvests in the same year. The magnitude of these correlations suggest that the association between brix in single stools and sucrose of the experimental clones may be stronger than it appears. In examining the progeny of the crosses, the relative frequency of high sucrose clones (15.5% sucrose or higher) was calculated for the entire progeny of each cross and for a selected progeny containing single stools in the upper 30% for brix. The relative frequency of high sucrose clones in the entire progeny was only half that of the selected progeny. Therefore, selection for high brix in single stools could have resulted in doubling the frequency of high sucrose experimental clones. The fact that selection in single stools for high brix is not completely effective emphasizes the need for a larger population of single stools to begin the program in order to obtain approximately the same number of entries in first line trials.

INTRODUCTION

Early, high sucrose is required of varieties to be used in Louisiana because of the relatively short growing season. Therefore, sugarcane breeders place extreme emphasis on selection for sucrose content and want to begin selection as early in the breeding program as possible. It has been shown that there is a relationship between brix, or percent total solids, and sucrose percent of cane. Lennox (7) showed that as early as 1917 there were records kept on the association between refractometer brix and sucrose. These measurements led to correlation coefficients of .875 to .974 between brix and percent recoverable sugar. In a separate experiment, he found a correlation coefficient of .707 between refractometer brix of the middle internodes of all the stalks in a stool and the percent recoverable sucrose from the entire stool. It was concluded that a hand refractometer brix reading is a reliable indicator of the percent recoverable sucrose. Christianson (3) found a very strong association, with $r = .9329$, between the refractive solids of mill juice and the refractive solids of juice punched from internodes in 111 comparisons. In 74 tests, he also found very strong associations between refractive solids of mill juice and polarization, $r = .9671$, and between refractive solids of several internodes of a large number of stalks and the polarization of these stalks, $r = .9022$.

This early work using brix as an indication of sugar content was done with a large number of stalks but has been supported by more recent work done with fewer stalks per sample. Hebert (4) found that the refractometer brix of 5 stalks from single stools, taken by several methods, was strongly associated with hydrometer brix of crusher juice from the same stalks, with correlation coefficients varying from .56 to .90.

Legendre (6) found that brix obtained in the laboratory by hydrometer was strongly associated with the sucrose content of cane. Hebert and Henderson (5) evaluated the breeding behavior of certain

^{1/} The assistance of the American Sugar Cane League, members of the U. S. Sugarcane Field Station, Houma, La. and the Louisiana Agricultural Experiment Station, Baton Rouge, La. made this research possible.

agronomic characters in 7 crosses in which the parents differed in sucrose level. They, too, found a strong association between hydrometer brix and sucrose content. In addition, the hand refractometer brix of 5 stalks was recorded for single stools of 7 crosses and for the plant cane and stubble crops of clones derived from the single stools. Correlation coefficients were calculated between brix in single stools and brix in each of 2 clonal plot years. The associations varied tremendously, with *r* values of the different crosses ranging from .21 to .72 and averaging .4. Because of the significance of the associations, they concluded that selection for refractometer brix in the field should be practiced, but because of the variation among crosses it should not be rigid.

Breaux, Duncelman and Chilton (1) reviewed 3 years of data on a series of crosses to provide some indication of the effectiveness of selection for refractometer brix at the individual stool stage. They used 3 brix readings from 3 stalks at different points on the stalk for each stool. For each series of crosses they found a significant positive association and concluded that selection in the individual stool for brix is effective to some degree in obtaining cane varieties with high sucrose content.

At both of the sugarcane breeding programs in Louisiana, single stool brix data were obtained and used for selection in earlier work. Then in the late 1950's this selection practice was discontinued for various reasons, one of which was the time consuming nature of the practice. Then, in 1968 the selection technique was resumed at the U. S. Sugarcane Field Station in Houma.

The problem of having to sample several stalks of a single stool in standing cane for refractometer brix could be partially solved if it were found that fewer stalks could provide an accurate sample. In Louisiana, 2 stalks are used to establish each selected single stool as a clone. Breaux and Duncelman (2) conducted an experiment to determine the reliability of a 2-stalk sample for the measurement of refractometer brix. They found that sampling 2 stalks after removal from the single stool nursery was as effective as the old method of sampling 5 stalks in standing cane. This new method was faster and provided satisfactory results, especially when new brix standards were set frequently during the selection period.

Because of the importance of hand refractometer brix in the present La. breeding programs, an experiment was conducted with one of its objectives to determine the effectiveness of selection for high hand refractometer brix in the single stool stage in obtaining high sucrose experimental clones.

MATERIALS AND METHODS

The experiment consisted of the unselected progeny of 4 biparental crosses in which the parents differed in sucrose content. The material was being grown in the stubble crop of the single stool stage at the U. S. Sugarcane Field Station in Houma, La. The parentages of the 4 crosses, along with their sucrose level based on numerous tests conducted over several years, are shown in Table 1.

Table 1. Parentage and progeny of the 4 crosses involved in the experiment.

Cross no.	Parentage	Relative sucrose level of parents ^{1/}
1	CP 52-68 x CP 48-103	I x MH
2	L 61-67 x CP 62-258	VH x H
3	CP 61-37 x L 62-96	I x H
4	L 60-25 x CP 57-614	H x H

^{1/} I = intermediate; MH = moderately; H = high; VH = very high.

It should be pointed out that 2 of the crosses, cross no. 2 (L 61-67 x CP 62-258) and cross no. 4 (L 60-25 x CP 57-614), had both parents high or very high in sucrose percentage. The other 2 crosses, cross no. 1 (CP 52-68 x CP 48-103) and cross no. 3 (CP 61-37 x L 62-96), had only 1 parent moderately high or high in sucrose percentage while the other parent in each cross was intermediate in sucrose percentage. In 1970, 100 single stools which were free of mosaic and possessed at least 4 stalks were randomly chosen from each of the 4 crosses. Four stalks were cut from each stool and 2 hand refractometer brix readings were made, each from 2 stalks. The hand refractometer readings were made from juice obtained with a Hawaiian-type punch from the middle of the 4th or 5th internode from the bottom of the stalk. The 4 stalks from each single stool were then bundled, given a number and used to plant a 10-foot clonal plot at the St. Gabriel branch of the La. Agric. Exp. Sta., along with 6 replications of each of the 8 parent varieties.

In 1971, in the plant cane crop, 10 stalks were harvested from each clonal plot by hand. Then in 1972, in the first stubble crop, 2 harvests were made. The first was in late October and the second was in late November or early December. In all 3 of the harvests, the 10 stalks from each clonal plot were cut, hand cleaned, and milled with an experimental mill to obtain about 60% extraction. The sucrose percentage of each clone was then determined by direct polarization of the undiluted juice after clarification. The polarization reading was converted to sucrose percentage by the use of Schmitz's table (8). In each cross there were several of the experimental clones which did not produce a

sufficient number of stalks to be included in the harvest. The number of clones per cross that were harvested varied from 89 to 94.

RESULTS AND DISCUSSION

The sucrose percentage of the parents in each of the 3 harvests and means of all harvests are shown in Table 2.

Table 2. Sucrose percentages of 8 parent varieties involved in the 4 crosses.

Parent variety	Sucrose %				
	1971 harvest	Early 1972 harvest	Late 1972 harvest	Mean of 1972 harvests	Mean of 1971 and 1972 harvests
CP 52-68	13.61	13.36	14.14	13.75	13.70
CP 48-103	13.81	13.01	15.37	14.19	14.06
L 61-67	15.62	16.28	17.20	16.74	16.37
CP 62-258	14.50	15.02	15.50	15.26	15.01
CP 61-37	13.56	13.28	14.39	13.84	13.78
L 62-96	16.69	15.10	16.50	15.80	16.10
L 60-25	13.79	15.02	15.06	15.04	14.60
CP 57-614	16.34	15.59	16.44	16.02	16.12

On Sept. 16, 1971, Hurricane Edith caused moderate to severe damage to the experiment. It can be seen that the sucrose levels of L 60-25 and CP 48-103 are somewhat below normal for that reason, possibly as a result of the storm. This effect may also have influenced the results of the experimental clones. However, in both of the 1972 harvests there was a normal behavior of the parents and this is reflected in the mean sucrose percentage of the 3 harvests.

In determining the effectiveness that selection for high single stool brix would have had on sucrose level, the association between brix in single stools and sucrose percentage of the clones obtained from them was measured by calculation of correlation coefficients for each cross. Correlation coefficients were calculated between single stool brix and sucrose percentage of the clones in each harvest, between single stool brix and the mean sucrose percentage of the 2 stubble harvests made of the clones in 1972, and between single stool brix and the mean sucrose percentage of the clones for the 3 harvests. The results are shown in Table 3.

Table 3. Correlation coefficients between brix in single stools and sucrose percent of clones derived from them for 4 crosses.

Characters correlated	Correlation coefficients for cross no.			
	1 ^{1/}	2	3	4
Brix of single stools and sucrose % of progeny in 1971 harvest	.50 ^{2/}	.39	.34	.34
Brix of single stools and sucrose % of progeny in early 1972 harvest	.50	.52	.60	.57
Brix of single stools and sucrose % of progeny in late 1972 harvest	.43	.48	.53	.47
Brix of single stools and mean sucrose % of progeny of both 1972 harvests (early and late)	.52	.54	.63	.59
Brix of single stools and mean sucrose % of progeny of both 1972 harvests (1971 and 1972)	.55	.54	.59	.58

^{1/}Cross no. 1: CP 52-68 x CP 48-103; Cross no. 2: L 61-67 x CP 62-258; Cross no. 3: CP 61-37 x L 62-96; Cross no. 4: L 60-25 x CP 57-614.

^{2/}All r values are significant.

For each harvest and for all 4 crosses there was a significant, positive association of moderate degree between single stool brix and sucrose percentage of the clones derived from them. These correlation coefficients show a moderate tendency for high brix single stools to produce high sucrose experimental clones, which indicates that selection for high brix among single stools would have been moderately but not highly effective in obtaining high sucrose clones.

It should be pointed out that the correlation coefficients, though only moderate in magnitude, tended to be consistent for the different crosses. With the exception of the first harvest, there was no more than .1 difference between the r values of the different crosses. The r values for the different crosses are most consistent for the association between single stool brix and mean sucrose percentage of the clones for the 3 harvests, with values ranging only from .54 to .59. This might be expected since the mean sucrose is an average of 2 growing seasons. This suggests that the association between brix of the single stools and sucrose of the clones derived from them was relatively constant for all crosses, regardless of the sucrose content of the parents, indicating that selection based on brix of single stools would have been equally effective for the 4 crosses despite differences in sucrose level.

For comparison with the data in Table 3, the correlation coefficients between sucrose percentages of the clonal plots in the different harvests are presented in Table 4.

Table 4. Correlation coefficients for sucrose percentage between different harvests of clonal plots representing the progenies of 4 crosses.

Characters correlated	1 ^{1/}	Correlation coefficients for cross no.		
		2	3	4
1971 harvest and early 1972 harvest	.61 ^{2/}	.45	.43	.32
1971 harvest and late 1972 harvest	.62	.41	.41	.33
1971 harvest and mean of 1972 harvests	.67	.47	.46	.38
Early 1972 harvest and late 1972 harvest	.71	.65	.69	.59

^{1/} Cross no. 1: CP 52-68 x CP 48-103; Cross no. 2: L 61-67 x CP 62-258; Cross no. 3: CP 61-37 x L 62-96; Cross no. 4: L 60-25 x CP 57-614.

^{2/} All r values are significant.

These associations between sucrose percentages of the clones in the various harvests are highly significant but only slightly higher than those between single stool brix and sucrose. This indicates that the clones were not entirely consistent in relative sucrose content at different harvests and that the association between brix in single stools and sucrose of the experimental clones derived from them may have been more reliable than it appears to be from the correlation coefficients presented in Table 3. It is apparent that the primary reason why the correlation coefficients between brix in single stools and sucrose content of clones derived from them were only moderate in magnitude was not a defect in the relationship between single stool brix and sucrose of the clones but an inconsistency in relative level of soluble solids, including sucrose, during different seasons and even at different harvest dates during the same season. Actually, the correlation coefficients in Tables 3 and 4 suggest that selection for high level of brix in the single stool stage would have been almost as effective in obtaining high sucrose clones as would selection for high sucrose in clonal plots in a single season.

The effect of selection for high single stool brix on the general sucrose level of the clonal progeny is shown in Table 5.

Table 5. Mean sucrose percentage (3 harvests in 1971 and 1972) for clonal plots of the entire progeny and for progenies derived from single stools having high and low brix.

Cross	Mean sucrose % of progeny from		
	Entire population	High-brix single stools ^{1/}	Low-brix single stools ^{2/}
CP 52-68 x CP 48-103	13.24	13.85	12.14
L 61-67 x CP 62-258	14.75	15.50	13.99
CP 61-37 x L 62-96	14.51	15.15	13.46
L 60-25 x CP 57-614	14.41	15.16	13.75

^{1/} Mean of clones in the progeny derived from single stools in upper 30% for brix.

^{2/} Mean of clones in the progeny derived from single stools in lower 30% for brix.

The mean sucrose (average of all 3 harvests) for the clones of the entire progeny for each cross is presented along with the mean sucrose percentage for clones derived from 2 selected progenies. These selected progenies consist of clones derived from the highest 30% of single stools for brix and clones derived from the lowest 30% of single stools for brix in each cross. For each of the 4 crosses, the mean sucrose of the clones derived from the highest 30% of single stools in respect to brix was appreciably higher than the mean sucrose of the entire, or unselected, clonal progeny. The difference was fairly constant for the crosses, ranging from .61 to .75% sucrose. Also, the mean sucrose of the clones derived from the lowest 30% of single stools for brix was considerably lower than the mean sucrose of the entire clonal progeny. This difference was not as constant for all 4 crosses. For all 4 of the crosses the difference between the mean of the clones derived from the highest 30% of the single stools and the mean of those derived from the lowest 30% is rather constant at 1.5% sucrose.

Although the effectiveness of selection for brix in single stools on the mean sucrose level of the progeny is relevant to the research, the effect of this selection on the relative frequency of clones with high sucrose is of greater importance in relating the results to a sugarcane breeding program. In Table 6, the relative frequency of clones in the entire, or unselected, progeny of each cross which were high in sucrose (15.5% sucrose or higher) are shown. Also presented is the relative frequency of high sucrose clones from a selected progeny of each cross resulting from the highest 30% of the single stools in refractometer brix.

Table 6. Frequency, in percent, of clones with mean sucrose of 15.5% or higher in entire progeny (unselected population) and in progeny derived from high-brix single stools (selected population) for 4 crosses.

Cross	% progeny 15.5% sucrose or higher	
	Entire progeny	Selected progeny ^{1/}
CP 52-68 x CP 48-103	8	15
L 61-67 x CP 62-258	37	62
CP 61-37 x L 62-96	22	31
L 60-25 x CP 57-614	20	44

^{1/} Single stools were in upper 30% in refractometer brix for the cross.

It can be seen that the relative frequency of high sucrose clones in the selected progeny was approximately twice that of the unselected progeny. Thus, for each of the 4 crosses there would have been a considerable increase in the relative frequency of high sucrose clones through selection for high brix in the single stool stage of a breeding program. It should also be emphasized that, in relative terms, the degree of improvement in frequency of high sucrose clones in the progeny through selection in the single-stool stage for high brix would have been similar for each of the crosses.

It is easily seen that the relative frequency of high sucrose clones was affected primarily by the parentage of the cross involved. This is in agreement with results from previous research by other authors. The parents of cross no. 1, CP 52-68 x CP 48-103, had the lowest mean sucrose percentage of the 4 sets of parents in the study, and, as shown in Table 6, this cross had the lowest relative frequency of clonal progeny with a sucrose percentage of 15.5 or higher. Furthermore, cross no. 2, L 61-67 x CP 62-258, had the highest mean sucrose percentage for its parents and also the highest relative frequency of clonal progeny with sucrose percentage of 15.5 or higher.

The number of single stools that were capable of producing high sucrose clones but would have been discarded because of low brix if selection had been practiced in the single stool stage is of importance because they represent valuable material that would be lost in a breeding program. To evaluate this aspect of the effectiveness of selection for brix in single stools, the progenies of all crosses were combined to form a population of 352 unselected single stools. Of the entire 352 single stools, there were 76 which produced clones with a mean sucrose of 15.5% or higher for the 3 harvests. By using very rigid selection with a minimum brix level of 19.2, 10% of the entire population of 352 single stools, or 35 single stools would have been selected. Of these 35 single stools, 15 proved capable of producing high sucrose clones. Thus, since the 352 single stools contained 76 which were capable of producing high sucrose clones but only 15 would have been selected at a 10% selection rate, 61 of the 76 superior single stools, or 80%, would have been discarded. This is only a small improvement over the 90% of superior single stools that would have been lost under a 10% selection rate that did not include brix data. Therefore, under very rigid selection, as in the highest 10% of single stools by brix, there would have been a great deal of work involved and yet the frequency of single stools lost that were capable of producing high sucrose clones would have been reduced only from 90% without brix data to 80%.

On the other hand, by using very liberal selection for brix with a minimum brix level of 17.3, approximately 50% of the 352 single stools would have been selected. Of these selected single stools, 51 produced high sucrose clones. Thus, at a 50% selection rate based on brix of the single stools, 51 of the 76 superior single stools would have been kept, representing 67%, which means that only 33% of the single stools capable of producing high sucrose clones would have been discarded because of low brix. If there had been no selection for brix in the single stool stage and 50% had been retained on the basis of other traits, approximately 50% of the single stools capable of producing high sucrose clones would have been lost. Therefore, in very liberal selection represented by a 50% selection rate based on single stool brix there would be an extraordinary amount of work and time involved to reduce the frequency of superior single stools that is lost from 50% to 33%.

The data suggest that a minimum brix level should be adopted which would allow 30-40% of the population of single stools to be selected. (Before beginning to determine the refractometer brix of a population of single stools, the original number should be reduced drastically by visual selection for such characters as stalk length and diameter and plant vigor). In the present study a selection rate, based on brix, of 30% would have resulted in the selection of 37 and the loss of 39 single stools which proved capable of producing high sucrose clones. Thus, the loss of superior single stools under a 30% selection rate would have been 50%, compared to the 70% that would have been lost with no selection for brix in the single stools.

If an approximately 30% selection rate based on brix of single stools is to be adopted and approximately 5,000 single stools are to be advanced to first line trials, it will be necessary to make brix determinations on about 15,000 single stools. Since these 15,000 single stools should be the remainder after visual selection for stalk characteristics, it is apparent that a large initial population of single stools would be required.

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CP 65-357, A NEW SUGARCANE VARIETY FOR LOUISIANA^{1/}

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ABSTRACT

CP 65-357 is a clone from a cross between CP 52-68 and CP 53-17. The cross was made at Canal Point, Florida, during the 1960 crossing season. It was selected in the clonal stage at Houma, Louisiana. Results from extensive replicated yield trials indicate CP 65-357 is outstanding in both tons of cane per hectare and kg of sugar per ton of cane. Yield data from multiple-location tests indicate it will be well adapted to all areas and soil types of the Louisiana sugarcane producing area. A major advantage of CP 65-357 is its ability to produce high yields and yet remain erect. Mosaic spread data indicate CP 65-357 is susceptible to mosaic, but limited mosaic yield trials suggest that it is tolerant to the disease. CP 65-357 is also being tested in Florida and Texas to determine whether it is adapted to those areas.

INTRODUCTION

The Louisiana sugarcane industry relies on new and better varieties for its survival. But for the imported POJ varieties, the industry would not have survived the low yields of 1925-26 (1). The POJ varieties, although susceptible to mosaic, were tolerant to the disease and maintained the industry until they were replaced by the Co and mosaic-resistant CP varieties.

The US Sugarcane Field Station at Houma, Louisiana, was established during this critical period of low sugar yields. Personnel at the Houma Station have participated in the testing and release of 31 varieties to the sugar industry. They consisted of 2 Co, 1 NCo, 3 L, and 25 CP varieties (9).

The sugar industry is presently growing 1 NCo variety, 3 L varieties, and several CP varieties. Hopefully, CP 65-357 will help maintain and increase sugarcane yields obtained from these varieties.

DEVELOPMENT AND TESTING

CP 65-357 was selected and tested under the 3-way agreement by the USDA, the La. Agric. Exp. Sta., and the American Sugar Cane League. CP 65-357 is a clone derived from a cross between CP 52-68 and CP 53-17. The cross was made at Canal Point, Florida, during the 1960-61 crossing season. The variety was selected in the seedling stage and reselected in the clonal stage at the Houma Station over a 5-year period; stalk size, stalk height, sucrose content, and stalk solidness were used as criteria (3). The variety was then tested in nursery and replicated yield trials for 3 years in the infield programs at Houma and the La. Agric. Exp. Sta. in Baton Rouge (10).

Further testing in replicated trials at the multiple USDA and LSU outfield locations (4) took place for 3 years.

CP 65-357 was rated susceptible to mosaic in the infield tests but was nevertheless advanced to the outfield tests because it was outstanding from an agronomic standpoint. Mosaic counts made in the replicated outfield plots confirmed its susceptibility (5). CP 65-357 was dropped from the testing and increase program at the meeting of the variety advancement committee in 1970 because of its mosaic susceptibility. Mosaic-resistant varieties L 65-69 and CP 65-350 and moderately resistant varieties CP 66-376 and L 66-48 were all promising at that time. Although CP 65-357 was dropped in 1970, it had been planted in replicated outfield plots at 13 locations in 1969. The 1970 growing season was good and lodging was considerable when unusually heavy rains fell in Sept. and Oct. CP 65-357 had unusually good erectness under these conditions at all the outfield locations, whereas the mosaic resistant varieties L 65-69 and CP 65-350 were badly lodged.

Breaux (2) found it difficult to determine erectness of a variety in small clonal plots at one location. The larger outfield plots at 13 locations are better for assessing the relative erectness and harvestability of new varieties. Agronomists working at the outfield level agreed that yield data should be taken on CP 65-357 although these data are not normally taken on discontinued varieties. The outfield data showed that CP 65-357 was the most outstanding variety in yield in the combined analysis of 10 light soil experiments during 1970 (6). Studies of cold tolerance also showed that CP 65-357 had a high degree of mill-cane cold tolerance (8). Furthermore, many of the mosaic-resistant varieties under test were very disappointing in yield or harvestability. After a careful review of these data, the variety advancement committee decided to bring CP 65-357 back into the program and transfer it to the secondary increase stations in 1971.

^{1/} Based on research done cooperatively with M. J. Giamalva, Department of Outfield Sugars, Louisiana Agricultural Experiment Station, Baton Rouge, Louisiana.

1972 OUTFIELD RESULTS

Yield data from outfield tests are normally grouped into light soil and heavy soil. The industry has historically been divided into the Mississippi River-Bayou Lafourche, the Bayou Teche, and the Red River areas. A combined analysis is made for each group by using all experiments from all areas. The best varieties for the La. sugar industry are those that yield best as an average of all locations in the combined analysis. Major varieties occupy large acreages in all areas.

The yields of CP 65-357 were compared with those of commercial varieties in the 3 areas during 1972 (Tables 1 - 3). It was the highest yielding variety in sugar per hectare in the Mississippi River-Bayou Lafourche and Bayou Teche areas. CP 65-357 and L 65-69 were the highest in sugar per hectare in the Red River area. There was relatively little difference in ranking of varieties for the different areas. For example, CP 65-357 was the highest yielding variety and CP 52-68 was the lowest in all 3 areas. Therefore, a single combined analysis of the data for all locations from the 3 areas produced the same interpretation. A combined analysis of all areas is normally used for variety recommendations.

Table 1. Combined analysis of 4 plant cane experiments on light soil from the Mississippi River-Bayou Lafourche area during 1972.^{1/}

Variety	Tons cane per ha	Kg sugar per ton of cane	Kg sugar per ha
CP 65-357	82 a	103 a	8446 a
L 62-96	71 b	102 a	7242 b
L 60-25	67 bc	103 a	6901 bc
CP 61-37	81 a	85 c	6885 bc
L 65-69	64 c	102 a	6528 c
CP 48-103	70 b	91 b	6370 cd
CP 52-68	70 b	84 c	5880 d

^{1/} Means followed by the same letter are not significantly different at the 5% level of probability according to the Duncan Multiple Range Test.

Table 2. Combined analysis of 4 plant cane experiments from the Bayou Teche area during 1972.

Variety	Tons cane per ha	Kg sugar per ton of cane	Kg sugar per ha
CP 65-357	75 a	100 a	7500 a
L 62-96	69 b	95 b	6555 b
L 65-69	63 c	101 a	6363 bc
CP 61-37	73 ab	86 c	6278 bc
L 60-25	60 c	94 b	5640 c
CP 52-68	62 c	80 d	4960 d

Table 3. Results from a plant cane experiment from the Red River area during 1972.

Variety	Tons cane per ha	Kg sugar per ton of cane	Kg sugar per ha
CP 65-357	82 a	81 b	6642 a
L 65-69	68 bc	93 a	6324 ab
L 60-25	67 bc	87 ab	5829 bc
CP 48-103	74 ab	77 c	5698 bc
L 62-96	74 ab	77 c	5698 bc
CP 61-37	75 ab	69 c	5175 c
CP 52-68	63 c	70 c	4410 d

CP 65-357 seems well adapted to the heavier soil types, but yield data on those heavy soil experiments are still limited and are not shown here.

CP 65-357 is compared with the Louisiana commercial varieties for the more important variety characteristics in Table 4. Two major weaknesses of CP 65-357 are mosaic susceptibility and intolerance to RSD. It is as susceptible to mosaic as CP 52-68, and very difficult to rogue. CP 65-357 was impossible to rogue at several outfield locations, so we had to use mosaic-infected seed cane to establish the variety in the outfield tests. Limited data suggest that CP 65-357 is tolerant to the disease. The variety must be tolerant if it is to become a major sugarcane variety. CP 65-357 is susceptible and intolerant to RSD and growers are urged to heat treat their seed cane.

Table 4. Comparisons of CP 65-357 with other La. varieties for important characteristics.

Category	Similar to commercial variety	Description
Tonnage	CP 61-37	Very good
Sugar	L 60-25	Very good
Erectness	CP 52-68	Very good
Brittleness	CP 44-101	Fair
Cold tolerance	CP 61-37	Good
Mosaic susceptible	CP 52-68	Bad
Mosaic tolerance	L 62-96	Good
RSD tolerance	L 62-96	Bad
Borer resistance	CP 52-68	Good
Millability & Fiber	CP 52-68	Fair
Purity	L 60-25	Very good

Although CP 65-357 is susceptible to the major virus diseases, it rated good to very good for most variety characteristics important in Louisiana such as tonnage, sugar, erectness, cold tolerance, borer resistance, and purity.

A survey of Louisiana sugarcane growers conducted by Hicks (7) after the 1971 harvest season indicated the most desirable characteristic in a sugarcane variety would be ease of mechanical harvesting. CP 65-357 has shown very good erectness at the outfield level in the difficult-harvesting seasons of 1970, 1971, and 1972. CP 65-357 compares favorably with CP 52-68, the high standard for erectness, and should provide the sugar industry with a good harvesting variety.

Although CP 65-357 was selected and released for the Louisiana sugarcane industry, it is also being tested in Florida and south Texas. Preliminary data from these areas indicate it may be adapted to these regions.

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BREEDING FOR RESISTANCE TO MOSAIC STRAIN H IN LOUISIANA

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ABSTRACT

A breeding program to combine a high degree of resistance to strain H of sugarcane mosaic with high yield was initiated in 1960. Interspecific hybrids with the highest degrees of resistance were identified and hybridized with high-yielding susceptible varieties, and selection pressure was increased in seedling and early clonal progenies. Because of the narrowness of the genetic base of the few resistant interspecific hybrids available (only two original *Saccharum spontaneum* L. varieties), several hundred *S. spontaneum* clones were screened for mosaic resistance. One form, US 56-15-8, yielded some clones in the BC₂ progeny within the commercial range for most agronomic characteristics, yet highly resistant to mosaic. BC₃ and intercross progeny of these clones are presently being screened. The behavior of these crosses is compared to that of crosses from the old breeding lines. Although it will be necessary to release high-yielding, susceptible but tolerant varieties for the present, these data indicate that resistant high-yielding varieties will again be available in the future.

HISTORY OF MOSAIC

The role that sugarcane mosaic played in the decline of the Louisiana sugarcane industry in the mid-1920's needs no retelling. The disease was an important cause of yield reduction for 25 years, until highly resistant CP varieties replaced the susceptible but tolerant POJ and Co varieties. The breeding of resistant varieties eliminated mosaic as a major disease problem for more than 15 years. In 1956, Abbott (1) noticed an unusual amount of mosaic spread in commercial fields of NCo 310 and CP 44-101 in Lafourche and St. Charles Parishes. The rapid spread of mosaic in the susceptible NCo 310 was surprising, and infections as high as 28% in plant-cane fields of the supposedly resistant CP 44-101 were totally unexpected. Abbott correctly surmised that Louisiana had a new strain of sugarcane mosaic virus (SCMV). He later described it as strain H (3).

Although he did not immediately predict the extent to which the new strain of mosaic would spread, Abbott noted that it could infect the major commercial variety CP 44-101. NCo 310, which was then being increased, was highly susceptible, and the newly released CP 52-68 was also susceptible -- all of which pointed to the possible danger of another mosaic epidemic. Abbott recommended to growers that they resume rogueing their fields. He initiated studies into the susceptibility and tolerance to the new strain of the major commercial varieties, promising unreleased varieties and potential parent varieties.

In 1959, Abbott (2) reported that, of the most promising commercial varieties, CP 52-68 was the least tolerant to mosaic, CP 44-101 was intermediate but also relatively tolerant, and NCo 310 was tolerant and least affected by Mosaic. He also noted that of the 8 varieties recommended for commercial production in 1959, only 3 -- CP 36-13, CP 47-193, and CP 44-155 showed a high degree of resistance to mosaic. The resistant varieties produced less sugar per acre than CP 44-101, CP 52-68, or NCo 310, were generally less adapted, and had other undesirable agronomic characteristics that limited their usefulness as commercial varieties. Although Abbott warned that mosaic spread in NCo 310 was so rapid it was impossible to control the disease in this and other susceptible varieties grown near it, he pointed out that NCo 310 was tolerant and would give satisfactory and perhaps higher yields than the resistant varieties that would have to be substituted for it.

Since there were no high-yielding commercial varieties resistant to strain H, it was necessary for the Louisiana sugar industry to rely on mosaic-susceptible varieties throughout the 1960's and to the present. Strain H spread rapidly throughout the sugarcane belt, and, except in the northern area and a few properties elsewhere, the disease can no longer be controlled in Louisiana's commercial sugarcane crop.

Fortunately, the interspecific hybrids, particularly NCo 310, were tolerant to strain H. Furthermore, the active breeding programs of the USDA and the Louisiana Agricultural Experiment Station provided

^{1/} Research at this location is done in cooperation with the Louisiana Agricultural Experiment Station.

the industry with new susceptible varieties, but either mosaic-tolerant or high-yielding, almost as fast as older varieties succumbed to infection. L 60-25, though intolerant, was released relatively free of mosaic, and was available for partial replacement of CP 52-68 acreage that became saturated with mosaic. The more tolerant L 62-96 and moderately resistant CP 61-37 are presently replacing much acreage of the saturated non-tolerant L 60-25. Presumably, if it is tolerant, CP 65-357, to be released in 1973, will hasten this replacement of CP 52-68 and L 60-25. This has played a major part in minimizing the harmful effects of the disease.

Major yield reductions from mosaic have thus far been avoided. In fact, sugar-per-acre yields increased steadily in Louisiana in the 1960's in spite of this worsening mosaic situation (8).

However, the forced reliance on mosaic-susceptible varieties in this latest epidemic was not without its disadvantages and financial losses to the Louisiana sugar industry. Growers had to return to rogueing seed plots, particularly of susceptible, intolerant varieties. Not only was rogueing costly, but more often than not, mosaic could not be controlled in these susceptible varieties. Replacement of susceptible, intolerant varieties was not complete; in fact more than half of the 1973 crop was planted to CP 52-68 and L 60-25. Much of the acreage of these varieties is saturated with mosaic. The industry could conceivably lose millions of dollars from mosaic in CP 52-68 and L 60-25 in 1973 alone. Yields increased during the 1960's in spite of mosaic. Actually, mosaic strain H robbed the Louisiana sugar industry of gains it made in variety improvement, better borer control, better weed control, improved drainage, and better farming.

A tremendous pool of mosaic inoculum was built up in the 1960's in all but the Northern area of the Louisiana sugarcane belt. Field spread is so intense that rogueing, although still recommended, is of little practical value for mosaic control on a commercial scale in many areas. The increased rate of mosaic spread in susceptible and even moderately resistant varieties is alarming. CP 52-68, released in 1958, was kept below the mosaic saturation point for almost 10 years after its release. L 60-25, released in 1966, has been saturated with mosaic for several years. L 62-96, released in 1969, is already almost 100% mosaic-infected in the Western area of the belt. There is little mosaic-free seed of CP 65-357 for release to sugarcane growers in the fall of 1973. Field spread of mosaic is now so intense it is extremely doubtful that the industry can use a mosaic-susceptible variety that is not tolerant to strain H of sugarcane mosaic.

The mosaic virus has shown a surprising stability in this tremendous pool of inoculum. Only one other strain (strain I) has been positively identified in Louisiana since 1958 (9). Although it is significantly more damaging to current commercial varieties than strain H, it has not spread as rapidly as the latter strain (10).

Everyone in the Louisiana sugarcane industry recognizes that the use of mosaic-tolerant varieties was a necessary stopgap measure; varieties with high mosaic resistance and equally high yielding ability would be greatly preferred. Commercial varieties have changed since Abbott described the mosaic strain H-variety complex in 1959 (2). However, the situation today is very much like the one he described 14 years ago. L 62-96 and CP 65-357, infected with mosaic, will produce satisfactory and perhaps higher yields than the more resistant varieties that can be substituted for them, namely, CP 48-103, CP 61-37, and L 65-69. Consequently, growers must still rely on susceptible, tolerant varieties.

Abbott and Zummo (4) predicted that breeding high-yielding mosaic-resistant varieties would be even more difficult than in the past, because of the scarcity of resistant germplasm among promising interspecific hybrids and because of the susceptibility of the *S. spontaneum* clones (5) that formed the genetic base for mosaic resistance in Louisiana sugarcane varieties. This has certainly been the case; however, measurable progress has been made in identifying new sources of resistance to SCMV strain H and in broadening the genetic base for resistance. It is the purpose of this paper to summarize these efforts.

VARIETY RESISTANCE TO STRAIN H

Resistant Interspecific Hybrids.

Abbott and Zummo (5) found that only 9 of 337 potential parent varieties remained completely free of mosaic at Waterford Plantation in the Mississippi River area between 1960-1962. Most of the resistant varieties were not considered high-quality parents from an agronomic standpoint, and some were abandoned on the basis of their poor performance in crosses. Only 3 of these resistant varieties, CP 33-229, CP 36-13, and CP 50-40, were subsequently used as parent clones (Table 1). Continued field-exposure trials by agronomists and pathologists have since identified 11 additional resistant interspecific hybrids suitable as parent canes. They were introduced into the crossing program as soon as they were identified. One of these varieties, L 65-69, was released to the industry in 1972.

Table 1. CP and L varieties with resistance to mosaic strain H in the field and greenhouse which have been used as parents since 1962.

Resistant varieties	Moderately resistant varieties	
	(1)	(2)
* CP 33-229	* CP 33-224	CP 61-37 ^{1/}
* CP 36-13	* CP 33-372	L 62-86
* CP 50-40	* CP 44-154 ^{1/}	CP 67-411
CP 60-16	* CP 44-155 ^{1/}	CP 68-338
CP 61-39	* CP 46-115	CP 68-350
CP 61-84	* CP 48-103 ^{1/}	CP 68-361
CP 65-350	* CP 51-21	CP 68-378
L 65-69 ^{1/}	* CP 51-24	CP 68-383
CP 66-376	* CP 52-1	L 68-89
CP 67-404	* CP 53-5	CP 69-312 ^{2/}
CP 67-424	* CP 55-38	CP 70-300 ^{2/}
CP 69-373	* CP 56-8	CP 70-327 ^{2/}
CP 70-317 ^{2/}	* CP 57-521	CP 70-330 ^{2/}
CP 70-401 ^{2/}	* CP 57-614	L 70-65 ^{2/}

* Varieties identified by Abbott and Zummo (4).

^{1/} Commercial varieties.

^{2/} Limited spread data, ratings subject to change.

Abbott and Zummo (5) also identified some moderately resistant interspecific hybrids that took but little mosaic at Waterford. Some of these were better agronomically than the more resistant varieties and were already being widely used as parents in the commercial breeding program. The list of moderately resistant varieties has also been substantially lengthened since 1962 (Table 1). One of these moderately resistant varieties, CP 61-37, was released to the industry in 1969. Moderately resistant varieties like CP 61-37 would require little roguing and remain relatively mosaic-free in light or moderate spread areas. However, they take considerable mosaic in heavy spread areas, and a careful roguing program would have to be followed to control mosaic in these varieties.

Resistance from New *S. spontaneum* lines.

More than 260 clones of *S. spontaneum* were artificially inoculated and screened for resistance to sugarcane mosaic from 1964-1968 at the Houma station (7). Thirty-two apparently immune *S. spontaneum* clones were studied in detail, and 10 new breeding lines for mosaic resistance are in various stages of backcrossing and selection.

US 56-15-8, a *S. spontaneum* from northern Thailand, was one of the highest sucrose *S. spontaneum* clones of the 32 clones studied. Records showed that US 56-15-8 was crossed by C. O. Grassl to CP 52-1 in 1959 and backcrossed to CP 57-101 and Cl 54-134 in 1961 (Fig. 1). Two of the BC₁ progeny (CP 63-561 and CP 63-571) were selected at Houma in 1963 and returned to Canal Point. We requested and received BC₂ progenies of US 56-15-8 at Houma in 1967.

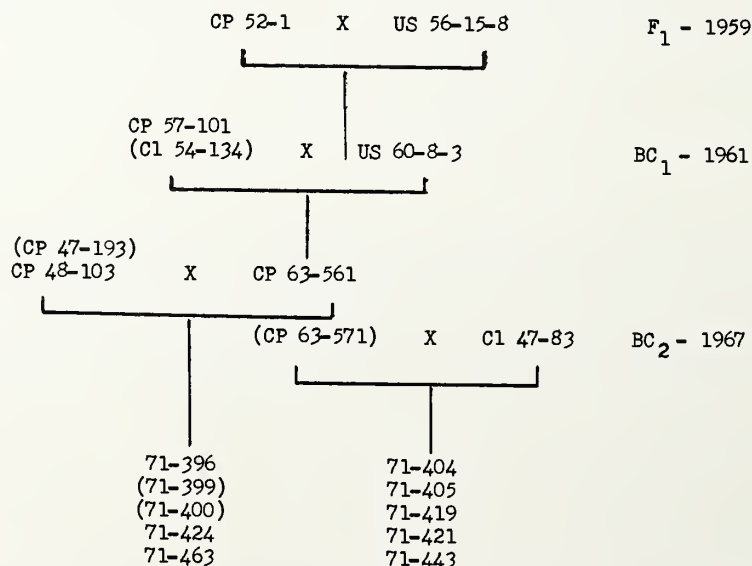


Fig. 1. Parentage of the CP 1971 varieties used as new sources of mosaic resistance at Houma and Canal Point in 1973.

The BC₂ progenies were surprisingly promising agronomically and yielded varieties of apparent commercial caliber. Eight of these varieties are being tested as commercial possibilities. In 1972-73, breeders used 10 of these BC₂ clones (1971 CP varieties) extensively in crosses (Table 2). None of the 10 varieties had ever taken mosaic in severe greenhouse-inoculation tests; however, CP 71-400, CP 71-405, and CP 71-421 recently took significantly more mosaic than L 65-69 in a preliminary field-exposure test (data not shown).

Table 2. Number of seedlings transplanted to field from BC₂ progeny of a new source of mosaic resistance, US 56-15-8 (*S. spontaneum*), in 1973.

Variety	Seedlings set to field
CP 71-396	720
399	1,084
400	2,518
404	2,631
405	5,326
419	6,517
421	924
424	3,226
443	5,931
463	1,866
Total	30,743

Mosaic resistance can still be found in the BC₂ progenies that were tested in the greenhouse this spring. The average percentage of healthy seedlings in BC₃ progenies and intercross progenies from US 56-15-8 crosses was higher than in progenies from the old breeding lines (Table 3). Mosaic infection was recorded in 300 seedlings of each progeny 30 days after inoculation with a mixture of strains H and I extracted from Rio sorghum at 1:10 dilution.

Table 3. The average percentage of healthy seedlings in progenies from old resistance sources and from US 56-15-8 (*S. spontaneum*) crosses after inoculation with mosaic in the greenhouse.

Mosaic reaction of parent clones	Source of resistance	No. crosses	Mean % healthy seedl.	Range % healthy seedl.	$\bar{sx}$
Susc. X Mod. res.	Old lines	9	10.1	5.3 - 15.9	+ 1.51
Susc. X Res.	Old lines	4	14.3	10.2 - 20.0	+ 2.31
Susc. X Res.	US 56-15-8	7	28.0	17.5 - 46.1	+ 4.03
Mod. res. X Res.	US 56-15-8	11	41.1	26.1 - 50.6	+ 2.23
Res. X Res. ^{1/}	US 56-15-8	5	57.2	35.6 - 76.2	+ 7.40

^{1/} Intercross progeny.

Only 10.1% of the seedlings that came from 9 crosses from susceptible x moderately resistant interspecific hybrids of old breeding lines remained free of mosaic after inoculation. The frequency of healthy seedlings was also low (14.3%) in 4 L 65-69 (susceptible x resistant) progenies. Twice as many seedlings remained healthy when the 1971 CP varieties from US 56-15-8 were crossed to susceptible CP and L varieties. Forty-one percent of the seedlings remained free in 11 progenies derived from crosses between the US 56-15-8 derivatives and moderately resistant CP and L varieties. More than half of the seedlings (57.2%) remained free of mosaic in the intercross progenies between the 1971 CP varieties from US 56-15-8.

RESISTANT GERMPLASM AND INCREASING SELECTION PRESSURE

The gradual accumulation of more and better sources of mosaic resistance has made it possible to test a greater number of seedlings from mosaic-resistant parents (Table 4). Fewer than 3,500 seedlings were transplanted to the field each year from mosaic-resistant parents in the period 1960-1962. Between 1970 and 1972, however, more than 45,000 of about 75,000 seedlings grown each year at Houma had at least one mosaic-resistant parent. All crosses, except those made for special purposes such as cold-tolerance or borer resistance, have at least a moderately resistant parent.

Table 4. Number of seedlings set to the field each year from crosses with varying degrees of mosaic resistance from 1960-1972, and the average number of seedlings eliminated by mosaic inoculation in the greenhouse.

Crossing years	Mosaic resistance of parent clones						% mosaic elimination
	R X R ^{1/}	R X MR	R X S	MR X MR	MR X S	S X S	
1960 - 1962	74	988	2,426	2,440	28,283	39,684	22.0
1963 - 1965	862	5,053	6,684	3,495	27,540	19,223	67.8
1966 - 1969	1,046	4,599	12,167	4,440	17,816	21,116	71.5
1970 - 1972	5,416	11,187	31,386	1,360	10,835	11,371	72.0

^{1/} R = resistant, MR = moderately resistant, S = susceptible.

Note also in Table 4 that selection pressure for mosaic resistance has increased in the greenhouse. In 1962, we adopted a spray method of inoculating seedlings, which increased the number of seedlings eliminated there to approximately 70%. In 1973, we began to use Rio sorghum as a source of inoculum, which provided a higher-titre inoculum and greater selection intensity than previously, when sugarcane was the virus source. Selection pressure has also been increased at other stages in the testing program.

DISCUSSION

The susceptibility to sugarcane mosaic strain H is inherited independently of susceptibility to the older mosaic strains. When strain H first appeared, the number of varieties resistant to the older strains was high, following 25 years of breeding and selection. However, susceptibility to strain H was widespread in the important commercial varieties, breeding canes, and varieties that were candidates for release. Strain H spread rapidly, thus fulfilling the final characteristic for becoming a dominant mosaic strain.

The scarcity of germplasm resistant to strain H was immediately apparent. It was particularly disappointing that not a single early-maturing, high-sucrose variety showed a high degree of resistance to strain H. Breeders were making progress in increasing yield in Louisiana by combining earlier high-sucrose with good cane tonnage. The need to return to low-sucrose canes for resistance to strain H was not a welcome prospect.

Although some of the resistant, low-sucrose varieties were returned to the crossing program, the bulk of the crossing effort for commercial varieties was still concentrated among moderately resistant, high-sucrose interspecific hybrids (Table 4). Understandably, the number of varieties with a high degree of resistance to mosaic remained low in these progenies.

Varieties now in outfield tests are from these series of crosses -- 1967 to 1969 CP assignments. The proportion of moderately resistant varieties at this stage in the testing program has shown a significant increase (6). However, highly resistant varieties still occur infrequently. Because so few of the varieties are highly resistant, we have been unable to select well adapted, high-yielding, resistant varieties.

However, several high-sucrose, moderately to highly resistant interspecific hybrids, like CP 61-39, CP 61-84, and L 65-69, were selected from these progenies. Other resistant varieties are being identified each year. It is possible now to include a high-sucrose, mosaic-resistant parent in almost every commercial cross. For instance, since 1970 we have selected more than 30,000 seedlings of the cross CP 65-357 (susceptible, high-sucrose) X L 65-69 (resistant, high-sucrose), and practically every seedling met the minimum sucrose standard in single stools. The frequency of resistant varieties should be greater in these progenies, at less sacrifice in sucrose content and agronomic characteristics than was possible with the parents that were available when strain H first appeared.

It was a surprising achievement to transmit mosaic resistance from a wild *S. spontaneum* clone (US 56-15-8) to varieties of commercial caliber or of good commercial breeding potential in less than 10 years after its resistance was recognized. Of course, this was in part because of the fact that the F₁ and BC₁ generations had been grown and selected before the value of this clone as a source of mosaic resistance was recognized. Other *S. spontaneum* lines have not "nobilized" as rapidly as US 56-15-8. However, this early success from the basic breeding program is encouraging, and other new lines are not too far behind US 56-15-8.

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MIXED INFECTIONS OF SUGARCANE WITH SUGARCANE
MOSAIC VIRUS AND MAIZE DWARF MOSAIC VIRUS

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ABSTRACT

Sugarcane varieties CP 52-68 and L 60-25 were mechanically inoculated with sugarcane mosaic virus (SCMV) strain H before or after inoculation with the serologically related strain A of maize dwarf mosaic virus (MDMV). Mixed infections with the 2 viruses resulted from the superimposed inoculations in both varieties, and rate of infection was higher on both varieties when they were inoculated first with MDMV. L 60-25 was more susceptible than CP 52-68 to mixed infections with the 2 viruses. No mixed infections with the viruses have so far been isolated from naturally infected sugarcane, but the results suggest the possibility that such mixed infections will occur in the field. Mixed infections with SCMV and MDMV have been isolated from a clump of itchgrass in a commercial sugarcane field.

INTRODUCTION

Plants can be infected with more than one related or unrelated virus at the same time (13).

Mixed infections of sugarcane plants with different sugarcane mosaic virus (SCMV) strains have been reported to occur naturally in the field and have been produced artificially by introducing 2 strains simultaneously or by superimposing one strain after another had been established in the plant (3). Similarly, Saccharum sinense Roxb. emend. Jeswiet cv. Chunnee was infected mechanically with a mixture of strain I of SCMV and of strain A of maize dwarf mosaic virus (MDMV) (10). The mixture was first established on itchgrass or raoulgrass (Rottboellia exaltata L.f.). Corn (Zea mays L.) infected with SCMV strain H (SCMV-H) (1) was observed not to cross protect against subsequent infection by MDMV (21).

There is no published report of mixed infections of commercial varieties of sugarcane with SCMV and MDMV, but mixed infections with the 2 viruses have been isolated from a clump of itchgrass in a commercial sugarcane field (16).

Sugarcane has been infected in the laboratory with MDMV both by aphids (14) and mechanically (5, 7, 8, 9, 12). Sugarcane naturally infected with MDMV has not been found.

Because MDMV-infected johnsongrass (Sorghum halepense (L.) Pers.) has become widespread in the Louisiana sugarcane belt since it was first observed in 1966 (18) and because there is evidence that SCMV and the serologically related MDMV (15, 18) are strains of the same virus (4, 19), experiments were conducted to determine whether mixed infections with these viruses can be established in commercial varieties of sugarcane.

MATERIALS AND METHODS

The experiments were conducted in an aphid-free greenhouse. Plants of sugarcane (Saccharum hybrid) varieties CP 52-68 and L 60-25 were established from single-bud cuttings in steam-sterilized soil in 3-in. peat pots. When the plants were 2 weeks old, they were inoculated with either SCMV-H or MDMV; the artist's air-brush method was used (6). One week later the plants initially inoculated with MDMV were similarly re-inoculated with MDMV. This was done because it is usually more difficult to infect sugarcane with MDMV than with SCMV. Two weeks after the second inoculation with MDMV, the plants that were first inoculated with MDMV were also inoculated with SCMV-H and vice versa; a combination of the pin-prick (17) and air-brush methods was used. Both methods of inoculation were used to increase the infection rate on these older plants. Plants of each variety inoculated with SCMV-H or MDMV alone and uninoculated control plants were also included in the experiments.

The SCMV-H inoculum was prepared from young leaves of the sugarcane variety POJ 234, and the MDMV inoculum was prepared from young leaves of johnsongrass. The inocula were prepared by grinding infected leaves in a meat grinder and adding 0.01 N sodium sulfite solution (about 2 ml/g tissue) and filtering the material through cheesecloth. Silicon carbide particles were added before air brushing.

Symptoms on the sugarcane plants were read over a 4-week period. At the end of this period, some of the plants with symptoms were assayed on sweet sorghum (Sorghum bicolor (L.) Moench) cv. Rio, johnsongrass, and sugarcane variety POJ 234. Some of the assay plants with symptoms were in turn assayed on Rio and Atlas sweet sorghums and johnsongrass to confirm the presence or absence of SCMV-H and MDMV.

^{1/} The technical assistance of P. M. Bergeron, Agricultural Research Technician, is gratefully acknowledged.

RESULTS AND DISCUSSION

SCMV-H produces a mild mosaic on Rio sorghum (20) and a severe necrosis with reddening and stunting on Atlas sorghum; johnsongrass is rarely infected (2). SCMV-H produces a green-on-green or yellow-on-green mosaic on sugarcane varieties POJ 234, CP 52-68, and L 60-25.

MDMV produces reddening and necrosis of leaf blade and spindle and stunting on Rio sorghum (11), mosaic symptoms on johnsongrass (12), and a mild mosaic on Atlas sorghum. POJ 234 is resistant to infection with MDMV.

Inocula from CP 52-68 and L 60-25 inoculated with SCMV-H alone produced a mild mosaic on Rio sorghum and POJ 234; johnsongrass was not infected. Three of 8 CP 52-68 plants inoculated with MDMV alone had mild, yellow-green streaks on the young leaves, whereas all 8 L 60-25 plants inoculated with MDMV had similar symptoms. Inocula from these leaves infected Rio sorghum and johnsongrass, but not POJ 234; symptoms on the Rio sorghum were those of MDMV.

Table 1 summarizes results from the superimposed inoculations. Inocula from 2 of 15 CP 52-68 plants with MDMV inoculated on plants infected with SCMV-H produced red flecking on the leaves and spindles and less stunting than MDMV alone on Rio sorghum and produced ordinary mosaic symptoms on johnsongrass and POJ 234. This indicated the presence of a mixture.

Inocula from a third plant of the 15 CP 52-68 plants produced typical MDMV symptoms on Rio sorghum and mosaic symptoms on johnsongrass and POJ 234. Assay of the inocula from POJ 234 on Rio and Atlas sorghums and johnsongrass showed that this third CP 52-68 plant had contained a mixture of SCMV and MDMV. Inocula from the other 12 CP 52-68 plants with MDMV inoculated on SCMV-H, when assayed on the test plants, showed the presence of SCMV-H alone. Thus, 3 CP 52-68 plants contained mixtures.

Inocula from 8 of 12 CP 52-68 plants with SCMV-H inoculated on MDMV produced mosaic symptoms on johnsongrass and POJ 234 and mild to severe MDMV symptoms on Rio sorghum. Assay of the test plants on Rio and Atlas sorghums and johnsongrass showed that both MDMV and SCMV-H were present.

Inocula from 3 of 16 L 60-25 plants with MDMV inoculated on SCMV-H produced mosaic on Rio sorghum, johnsongrass, and POJ 234 sugarcane; further assay of the johnsongrass showed that 2 plants had contained only SCMV and one plant only MDMV, indicating an unstable mixed infection.

Inocula from all 16 L 60-25 plants with SCMV-H inoculated on MDMV infected Rio sorghum, johnsongrass, and POJ 234 sugarcane. Assay of the test hosts indicated the presence of a strong mixed infection (Table 1). After the 16 L 60-25 plants had been infected for 1 year, the stalks were cut into single-bud seed pieces and germinated in vermiculite. The shoots from these were assayed after the symptoms had developed. One L 60-25 plant still contained a mixed infection after 1 year.

Table 1. Symptoms produced by inocula from sugarcane previously inoculated with MDMV and SCMV-H in succession.

Variety	Inoculation		Number assayed	Symptoms ^a on assay hosts ^b			Interpretation of virus in sugarcane
	1st	2nd		Rio	Johnsongrass	POJ 234	
CP 52-68	SCMV	MDMV	2	Atyp* ^c	+	+	mixed
CP 52-68	SCMV	MDMV	1	MDMs	+	+	mixed
CP 52-68	SCMV	MDMV	12	SCMs	-	+	SCMV
CP 52-68	MDMV	SCMV	8	MDMs*	+	+	mixed
CP 52-68	MDMV	SCMV	4	-	-	-	none
L 60-25	SCMV	MDMV	3	SCMs	+	+	mixed (weak)
L 60-25	SCMV	MDMV	13	SCMs		+	SCMV
L 60-25	MDMV	SCMV	16	MDMs	+	+	mixed

^a MDMs refers to symptoms associated with MDMV; SCMs refers to symptoms associated with SCMV; Atyp refers to symptoms not typical of either above; () refers to the presence of ordinary mosaic symptoms, and (-) to the absence of symptoms.

^b Rio (*Sorghum bicolor*); johnsongrass (*S. halepense*); POJ 234 (*Saccharum interspecific hybrid*).

^c (*) refers to the fact that these plants were assayed on Atlas and Rio sorghums, and johnsongrass. The results were used to obtain the interpretation of virus present.

Results show that mixed infections of commercial varieties of sugarcane with SCMV-H and MDMV can be obtained experimentally. Rate of the mixed infection with the viruses on varieties CP 52-68 and L 60-25 was higher if MDMV was the first introduced virus. L 60-25 was more susceptible than CP 52-68 to infection with MDMV and was also more susceptible to mixed infections with the two viruses.

No mixed infections with SCMV and MDMV has so far been isolated from naturally infected sugarcane, but the results suggest the possibility that such mixed infections will occur in the field.

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THE RECOVERY OF SUGARCANE FROM INFECTION WITH SUGARCANE MOSAIC VIRUS:
VARIETY CO 285 AND STRAIN D

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ABSTRACT

One-node cuttings from stalks of sugarcane infected with sugarcane mosaic virus may give rise to shoots free of this infection. The recovered shoots have no mosaic symptoms, even when grown for several vegetative generations, assay negative for the presence of virus, and are liable to infection when inoculated with mosaic virus. Studies of the recovery of cuttings of Co 285 from infection with strain D have shown the following: 1) the random distribution along the fully-grown stalk of buds giving rise to recovered shoots; 2) the lower incidence of recovered plants from cuttings given a single hot-water treatment; 3) the occurrence of an occasional plant with mosaic symptoms temporarily restricted to one leaf or to one of several shoots; and 4) the gradual increase in the number of plants with mosaic symptoms among the group of plants that do not recover. In turn, these results suggest the following: 1) that, on the fully-grown stalk, recovery is not related to age or position of the bud; 2) that virus is present in some of the cuttings which, without heat treatment, would probably be considered to be recovered; 3) that virus may be restricted in the shoots before the plant develops symptoms; and 4) that a subacute infection can persist in the population. These results may be interpreted to indicate that, in a shoot that will recover, virus may be localized for a transitory period without causing symptoms.

INTRODUCTION

It has been known for many years (6, 14) that it is possible to obtain symptomless shoots from the buds of sugarcane plants showing sugarcane mosaic disease symptoms. Such symptomless shoots have been called "recovered" shoots.

Observations and experiments on recovery in the intervening years have further defined and enlarged the concept. These results have indicated that:

- 1) When recovered plants are propagated, the progeny of succeeding vegetative generations remain free of symptoms of mosaic (16).
- 2) Recovery does not depend on how long the diseased plant has been infected with mosaic (21).
- 3) Recovery from sugarcane virus infection has been described for several species of grasses (6) besides sugarcane.
- 4) Different varieties, such as P0J 213, 228, and 234, may show markedly different proportions of recovery (21). These varieties were derived from the same parents.
- 5) Plants that have recovered may become infected again under field conditions (11), or by inoculation in the greenhouse (10), and recovery and reinfection may occur repeatedly (9).
- 6) Plants that have recovered do not yield infectious virus when assayed (10). The earlier finding that recovered plants may yield infectious virus (22) was based on the assay of plants recently recovered.
- 7) Summers, Brandes, and Rands (20) divided recovery into foliage recovery, where the symptoms are lost in the growing shoot (11, 14), and germination recovery, where the symptoms are absent in shoots developing from buds of infected stalks, either in tillering (11) or in propagation by cuttings (6).
- 8) Two adjoining buds on the same sett may produce shoots, one with mosaic symptoms, one without (22), and one stool may have both diseased and recovered shoots (11).
- 9) There appears to be no specific order in which the buds of a stalk are related to recovery (18, 21), although the shoots from the oldest and the youngest buds on a stalk may show reduced recovery as well as reduced germination (20).
- 10) For a particular strain of sugarcane mosaic virus, the overall proportion of buds that will recover, or the overall proportion of shoots that will recover, is a characteristic of the sugarcane variety (20, 22).

^{1/} Research at this location is done in cooperation with the Louisiana Agricultural Experiment Station.

11) For any one variety of sugarcane, the strain and substrain (isolate) of the virus may affect the proportion of plants recovered (20, 21). Abbott and Tippet (2) question recovery as a criterion of sub-strain classification, because they find that recovery is not a constant.

12) Varieties may show a high rate of germination recovery combined with a very low rate of foliage recovery (16), or high rates of germination recovery may be correlated with high rates of foliage recovery (20).

13) Some plants from the same source as recovered plants may show transient mosaic symptoms during the first few weeks of growth (20).

14) Mosaic-symptomed plants growing from the buds of foliage-recovered shoots tend to recover more rapidly and have recovered tillers sooner than those growing from the buds of mosaic-symptomed shoots (20).

These studies have given a composite of the characteristics of recovery. A sugarcane plant recovered from sugarcane mosaic virus disease is symptomless, assays negative for virus, and is susceptible to re-infection by sugarcane mosaic virus; the frequency of recovery is a function of the combination of a particular sugarcane variety with a particular virus strain or isolate. Thus, sugarcane recovers from the virus infection rather than just from the symptoms.

In several other diseases, though not in sugarcane mosaic, environmental factors affect the proportion of recovered plants. Bennett (5) reported that raspberry canes of a hybrid variety recover more quickly from leaf curl disease if they grow well. In sweet clover infected with wound tumor virus, Selsky (17) obtained markedly different frequencies of recovery among cuttings, depending on the age of the plants from which the cuttings were made and on the temperature at which these plants had been grown. Caudwell (1964), working with the "flavescence doree" disease of the grapevine (now considered a mycoplasmal disease), found recovery among cuttings affected by the maturity of the buds, with fully dormant buds giving rise to recovered shoots.

Recovery has been reported for at least 3 other diseases of sugarcane, chlorotic streak (1), streak (19), and sereh (14). These cases of recovery have not been critically evaluated.

The explanations of recovery, how parts of an infected sugarcane plant may give rise to a recovered plant, fall into 3 categories: the absence, the inactivation, or the attenuation of virus in these parts. Stahl and Faris (18) considered the virus to be absent because, they contend, the virus is unevenly distributed in the plant as a result of the resistance to infection of varieties that recover. Summers, Brandes, and Rands (20, p 107) disagreed in these words: "When, throughout an entire growing season, the successive new leaves formed by the terminal bud in elongation of the stalk have continuously shown symptoms, it is inconceivable that the lateral buds subtending those leaves should not also have been invaded by the virus." The discovery of transient symptoms suggested to these authors instead: "... that in certain cases, at least, recovery was not necessarily caused by the absence of virus from those eyes producing healthy shoots, but that it was probably initially present and later died or failed to multiply, and was strained out during germination or early growth of the young plant".

East (9) considered that recovery is caused either by viral inactivation or by viral attenuation. The concept of viral attenuation has been superseded in virology and replaced by the concept of selection of more-or less-virulent strains. The presence of less-virulent strains of virus has not been demonstrated in recovered sugarcane plants.

The other explanations of recovery, absence or inactivation of virus, are more likely. Viruses are not uniformly distributed in the plant, and in many diseases, the virus concentration varies widely from organ to organ and from time to time. It is not unusual for virus to be absent from the meristematic region; Leu (13) obtained healthy plants from cultured terminal buds taken from mosaic-infected plants. Several virus diseases are known, in which parts of the plant escape infection temporarily, e.g., abaca corms (15).

There are many examples of virus loss. The virus content in many diseases appears to be a balance between virus synthesis and destruction, and the virus concentration of leaves tends to decrease with age. Not all cells carry infectious virus, even when the cells are known to be derived from infected cells (8). That infections occur normally which do not lead to visible disease was shown by post-inoculation heating experiments (23).

This paper considers the recovery of sugarcane var. Co 285 from strain D of the sugarcane mosaic virus. The objective of this paper is to relate the infectious virus and the loss of symptoms, i.e., to determine if loss of symptoms involves recovery from infection, and, if so, to obtain some indication of when the infectious virus is lost in the development of the symptomless plant.

To simplify the description of the results, unless specified otherwise, "diseased" will refer to the presence of mosaic symptoms, "symptomless" to their absence in plants derived from diseased plants originally, "virus" to strain D of sugarcane mosaic virus, and "plant" to sugarcane of the var. Co 285.

MATERIALS AND METHODS

Plants of the sugarcane variety Co 285 (interspecific hybrid of *Saccharum*) were grown in screened greenhouses and were fumigated and fertilized weekly. The minimum temperature generally was between 20 and 25 C; the maximum temperature was not controlled.

The isolate of strain D of sugarcane mosaic virus used in these experiments has been in the strain collection at Houma for many years; it is maintained on the sugarcane variety POJ 234. Inoculum was prepared by grinding symptomed leaves of this variety in 0.01 N sodium sulfite with a mortar and pestle and straining through cheesecloth. Young plants of Co 285 were inoculated by airbrush (about 10 kg/cm²).

Cuttings or setts were prepared from the stalk, after all the leaves had been removed and the nodes had been numbered sequentially. The node with the youngest leaf with dewlap exposed was designated as Kuijper node 1, the next older as Kuijper node 2, etc. The cuttings were prepared with pruning shears dipped in alcohol and flamed between every cutting. The one-node cuttings usually were 6-cm long, with the leaf scar in the center.

After the appropriate treatments, the cuttings were planted in sterilized vermiculite in peat pots 7 1/2 cm in diameter. These pots were arranged on tamped sterilized soil in metal flats. The plants, which were grown in these flats for 3 to 6 months, were observed for mosaic symptoms repeatedly. If the plants were to be grown further, they were transplanted 3 to 4 months after planting, either into 15-cm pots or 9-liter pails. These plants, when 9 to 14 mo old, served as source of stalks for the next generation of cuttings, though sometimes cuttings were made directly from younger plants in the flats.

Top cuttings were prepared by cutting through Kuijper internode 5 or 8, removing the oldest one or two leaves entirely, and trimming the spindle and Kuijper leaf 1 from 2 to 7 cm beyond the dewlap of leaf 1. The blades of the remaining older leaves were cut back almost to the dewlap. The top cuttings were then planted directly into pots, with the oldest 1 or 2 nodes below soil level. In some experiments, the buds on the oldest, 1 or 2 were excised.

In a number of experiments, the cuttings were given a single hot-water treatment in a constant-temperature bath, which maintained the temperature of the circulating water within a fraction of a degree. The temperature used included 50, 52, and 54.8 C. The length of treatment ranged from less than 2 min to more than 2 hr. The cuttings were assigned to the heat treatment so that the number of cuttings from each stalk and the original position of the cuttings along the stalk were balanced. In experiments with 2 treatments, the cuttings along the stalk were assigned alternately; with more than 2 treatments, the cuttings were assigned so that the order along the stalk and the position on the stalk were randomized.

To assay for the presence of virus, the youngest leaves or the roots of sugarcane were ground in 0.01 N sodium sulfite with mortar and pestle, strained through cheesecloth, and inoculated to sorghum (*Sorghum bicolor* (L.) Moench, var. Rio) seedlings. The seedling leaves were dusted with silicon carbide, inoculated between thumb and fore-finger, and rinsed after inoculation; 20 to 50 seedlings at the 2-to 4-leaf stage were inoculated per sample. Symptoms were read 2 to 6 weeks later.

Sources of accidental spread of virus may have included the occasional entry into the greenhouse of a winged aphid, and the carry-over of virus on hands during assay. There was no indication of spread of virus by the manipulations needed to prepare the cuttings. The accidental spread of virus by aphids, which could be estimated from the incidence of infection among the many noninoculated plants in the greenhouse, was very limited.

RESULTS

Assay of Symptomless and Diseased Plants.

The spingle leaves of 10 symptomless and of 5 diseased plants were assayed individually. Nine of the symptomless plants indexed negative on Rio sorghum plants; a 10th indexed positive on 7 of 48 test plants, presumably due to carry-over of virus from the previous sample. All diseased plants indexed positive on nearly all Rio seedlings inoculated.

In another test, 2-mo-old plants propagated from diseased stalks were selected, 3 diseased and 7 symptomless, and from each plant a large part of the root system was removed and assayed. The plants were severely cut back, then observed for symptoms for an additional 6 weeks. Two of the plants originally symptomless became diseased during this period. The roots of the 3 diseased plants contained virus, and the roots of the 5 plants that remained symptomless assayed negative. The roots of 1 of the 2 plants that became diseased assayed positive, the other negative.

Inoculation of Symptomless Plants.

The response of symptomless shoots to inoculation was tested in 2 experiments. In the first experiment, the symptomless shoots from cuttings of a diseased plant were propagated for 2 vegetative generations. In the third generation, 8 young plants were inoculated, and 14 were left as controls. The 8

inoculated plants became diseased and were grown for 14 months before being divided. Among the vegetative progeny were some diseased and many symptomless plants. When grown for another generation, symptomless plants gave rise only to symptomless plants, whereas diseased plants gave rise to both diseased and symptomless plants. The 14 plants not inoculated remained symptomless.

In the second experiment, the vegetative progeny of an inoculated plant was diseased and remained diseased for 2 vegetative cycles. A symptomless axillary shoot that developed in an otherwise diseased stool was divided in 1969, and redivided through 4 short vegetative cycles. In each cycle, one or more plants were propagated, and all of the progenies were symptomless. Eight young plants, inoculated with virus in the fourth generation in 1971, developed mosaic symptoms, whereas those not inoculated remained symptomless. It may be concluded that symptomless plants, when inoculated with virus, can develop mosaic symptoms, and the inoculated plants may give rise to diseased and symptomless plants.

The Occurrence of Diseased and Symptomless Plants.

The relative frequency of diseased and symptomless shoots from the axillary buds of diseased stalks may vary widely. There are some symptomless plants in most experiments; the observed range has been from all to none.

When the tops of diseased stalks are used as cuttings and the terminal meristem continues its growth, the newly developing leaves, in nearly all cases, are diseased. A single symptomless plant resulted from 106 top cuttings in 8 experiments. In this one plant, the top, when recut, was again symptomless, whereas cuttings from the base of the plant gave rise to several diseased shoots. When top cuttings are made from symptomless plants, as was done in 4 different experiments with 31 tops, all remained symptomless.

The difference between top cuttings and stalk cuttings from the next older node was tested by pairing cuttings from the same diseased stalk. In 2 experiments, the top cutting included as its oldest node, Kuijper node 5, and the stalk cutting included node 6. In the third experiment, the comparable nodes were 8 and 9, respectively. For these 3 experiments, there were 16, 17, and 10 surviving pairs. All 43 tops were diseased, as were 10, 17, and 6, respectively, or a total of 33, of the shoots from stalk cuttings. The shoots from 6 in the first, and from 4 in the last experiment were symptomless. Four similar pairs from symptomless stalks were symptomless.

Observations of axillaries of top cuttings, as well as of plants, from a variety of experiments over the past 6 years have indicated that the disease is not always fully systemic. Axillary shoots of diseased mother shoots may be symptomless, and the vegetative progeny from these axillaries are symptomless also; the axillary shoots may be diseased and the mother shoot symptomless; or symptoms may be restricted to one or a few leaves, and the plant subsequently continues its growth without any further symptoms (transient symptoms). The loss of symptoms in a growing shoot that has had numerous diseased leaves is rare. The axillaries of a diseased mother shoot may include some diseased and some symptomless shoots; even shoots growing from adjacent buds on one mother shoot may differ. If the axillary shoots are removed, rooted, and grown, a majority of symptomless shoots may continue to be symptomless; diseased axillaries remain diseased.

Bud Position and Diseased and Symptomless Shoots.

The buds that give rise to diseased and those that give rise to symptomless shoots occur in no particular order on the stalk. The distribution of these buds appears to be random, both for a single stalk and among stalks, as indicated by the proportion of diseased and symptomless shoots in relation to node position. Node position and age, which coincide on a single stalk, need not be closely correlated among stalks because of differences in growth rate and emergence.

The proposition that clustering of diseased and symptomless shoots from buds along a stalk is not caused by chance alone may be tested by the "Runs Test for Randomness" (12, pp. 322-326). When this test was applied to 7 stalks with sufficient vegetative progeny to test for significance, none had clustering different from that expected by chance alone.

The association of the proportion of symptomless and diseased shoots with node position was examined in one experiment, in which 5 1/2-mo-old cane was divided. Every diseased stalk with mature nodes was classified according to the Kuijper number of the oldest node aboveground, and then single-node cuttings were prepared from all available nodes beginning with Kuijper node 5. There were 5 stalks with 16 to 19 nodes, 10 stalks with 13 to 15 nodes, 13 stalks with 10 to 12 nodes, 8 stalks with 7 to 9 nodes (of which 3 stalks had no living progeny and were discontinued), and 1 stalk with 5 nodes. Symptoms were noted after 75 days. Of 238 survivors from 263 nodes, 171 were diseased and 67 were symptomless (Table 1). A χ^2 test ($\chi^2 = 5.22$, 7 degrees of freedom) indicated no significant association between presence or absence of symptoms among survivors and position on the stalk.

Table 1. The presence or absence of symptoms on shoots derived from cuttings, classified according to their original position on diseased stalks.

		Kuijper node number on stalk														
		5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Total no.	of nodes	34	33	32	32	31	26	22	17	13	7	6	5	2	2	1
No. of survivors																
with symptoms	positive	24	20	19	25	20	16	10	11	8	5	4	5	2	1	1
	negative	8	8	11	6	7	7	8	5	4	1	2	0	0	0	0

Symptom Appearance: Rate and Plant Development.

The gradual appearance of symptoms among the progeny of diseased plants was followed in one experiment over a period of 4 months. Single-node cuttings were prepared Dec. 14, 1972, from Kuijper nodes 6 to 11 of 66 stalks. The cuttings from 16 symptomless stalks were distributed among the cuttings from 50 diseased stalks. The plants from these cuttings were grown first in flats, and then, from Mar. 5 on, in 15-cm pots. Plants were observed for symptoms at 1- to 3-day intervals for the first 3 months, and then less frequently until Apr. 16. Among the 113 cuttings from diseased stalks, 97 survived, and 57 of these were diseased; among the 37 cuttings from symptomless stalks, 30 survived, and 1 became diseased.

The number of diseased plants from diseased stalks was 4 by Jan. 19, 42 by Feb. 19, 55 by Mar. 19, and 57 by Apr. 16. The increment in total number of diseased plants over approximately monthly periods was 4, 38, 13, and 2, indicating that the cumulative frequency of diseased plants is related to time in an S-shaped curve. The number of diseased plants increased during 7- to 8-day periods of the second month as follows: 14 plants to Feb. 11, and 6 plants to Feb. 19.

The plants that became diseased varied widely in size at the time when their symptoms first became evident. The developmental stage of the plant was estimated by the leaf symptom number, i.e., the number of leaves with leaf blades that have developed on the mother shoot up to and including the oldest leaf with symptoms. Because the lamina of the first leaf with leaf blade generally is very small, the lowest leaf symptom number definitely identifiable is 2 and, in a few plants, 3. In this experiment, leaf symptom numbers were available for 55 plants from diseased stalks; of the other 2 plants, 1 had not had the number noted, and 1 developed symptoms only on axillaries. The leaf symptom numbers ranged from 2 to 10; the number of plants with leaf symptom no. 2 was 2 and then, sequentially, 4, 5, 13, 6, 7, 11, 4, and 3 (for leaf symptom no. 10). The median falls among the plants in the group of leaf symptom no. 6.

The gradual appearance of symptoms has been noted among the controls in heat-treating experiments.

The Effect of Hot-Water Treatment.

A single hot-water treatment of cuttings from diseased stalks tends to increase the proportion of diseased shoots and the rate at which symptoms first appear. A similar treatment of cuttings from symptomless stalks results only in symptomless shoots. As shown in Table 2, the hot-water treatments have included 50 C for 120 min and 52 C for 20 min; treatments at 54.8 for 3 1/2, 7, or 10 1/2 min were followed immediately by immersion in water at room temperature. The cuttings that were not heat-treated were planted directly or were dipped in water at room temperature before planting.

Table 2. The effect of a single hot-water treatment of cuttings from diseased stalks on the number of diseased and symptomless shoots produced.

Exp. no.	Begun (yr--mo)		Cutting to reading (days)	Treatment		Survivors				
				Temp. (C)	Duration (min)	Of total (%)	No. with mosaic			Symptomless (%)
							+	-	?	
1	67	9	87	-	-	100	-	3	-	100
				50.0	132	100	3	-	-	0
2	68	6	68	-	-	90	4	10	4	56
				50.5	110	95	17	2	-	11
3	69	3	90	-	-	90	6	30	1	81
				50.3	120	83	26	8	-	24
4	69	3	89	-	-	89	8	25	-	76
				50.3	120	76	14	11	1	42
				54.8	7	81	18	11	-	38
5	69	3	88	-	-	93	6	31	1	82
				50.3	120	86	25	11	-	31
6	69	9	97	-	-	89	19	14	1	41
				50.0	120	73	17	18	-	51
7	69	11	148	-	-	100	10	2	-	17
				54.8	7	100	5	5	-	50
8	70	6	61	-	-	85	30	11	-	37
				54.8	3.5	85	35	6	-	15
				54.8	7	94	38	7	-	16
				54.8	10.5	81	34	5	-	13
9	70	6	64	-	-	91	21	7	1	24
				54.8	3.5	94	28	2	-	7
				54.8	7	100	32	2	-	6
				54.8	10.5	79	21	4	1	15
10	72	2	119	-	-	74	16	9	-	36
				52.0	20	100	29	7	-	19

In the 4 experiments of Table 2 (Exp. 6, 8, 9, and 10) in which symptoms were noted frequently enough, the shoots from heat-treated cuttings developed symptoms more quickly than shoots from cuttings that had not been heat-treated (Table 3). This was true whether the heat-treatment increased the proportion of diseased plants (Table 2, Exp. 10) or not (Table 2, Exp. 6). In Exp. 8, (Table 3), the early termination of the experiment (after 61 days) may have limited symptoms among the shoots from non-treated cuttings; when the experiment was terminated, however, the more gradual development of symptoms among the nontreated was already well defined. As Exp. 9 was replication of Exp. 8 and gave similar results, it was not included in Table 3.

Table 3. The effect of a single hot-water treatment on the proportion diseased (as percent of total diseased) at various intervals after planting.

A. Exp. 6 of Table 2				
Interval since cutting (days)	Shoots diseased after treatment at 50 C (%)			
	0 min		120 min	
35	42		83	
46	53		100	
60	63		100	
78	84		100	
97	100		100	

B. Exp. 8 of Table 2				
Interval since cutting (days)	Shoots diseased after treatment at 54.8 C (%)			
	0 min	3 1/2 min	7 min	10 1/2 min
23	10	23	37	32
30	30	69	66	79
36	53	89	79	88
44	67	94	89	94
54	87	100	97	97
61	100	100	100	100

C. Exp. 10 of Table 2		
Interval since cutting (days)	Shoots diseased after treatment at 52 C (%)	
	0 min	20 min
26	6	55
36	38	90
47	56	97
84	100	100
119	100	100

The increase in the proportion of diseased shoots among the hot-water-treated cuttings was observed in the majority of the experiments, regardless of the particular combination of temperature and duration tested (Table 2). Preliminary results, not included in Table 2, indicated that a single treatment of 105 seconds at 54.8 C may be enough to increase the proportion diseased, though less effectively than a 3 1/2-min treatment.

Hot-water treatment did not always increase the proportion of diseased plants among the vegetative progeny. In Exps. 6 and 7 (Table 2) it did not do so, nor in a third experiment, not listed, in which all of the shoots from diseased stalks became diseased, whether heat-treated or not.

In Exps. 1 and 5 (Table 2), the mosaic-symptomed stalks were derived from cane that had been inoculated with the ratoon-stunting disease (RSD). The heat treatment used in these experiments generally is sufficient to cure RSD, but the progeny was not examined for nodal symptoms. Mosaic-symptomless shoots occurred among the vegetative progeny of diseased stalks, whether RSD was present or not.

Many of the experiments in Table 2, as well as experiments not listed, included cuttings from symptomless stalks. The cuttings, which numbered in the hundreds, were exposed to the same hot-water treatments as cuttings from diseased stalks. The shoots that developed from heat-treated cuttings of symptomless stalks were symptomless.

DISCUSSION

The results presented indicate that the mosaic-symptomless shoots growing from cuttings of diseased stalks are shoots recovered from infection. These shoots usually assay negative for virus, are symptom-free, and are susceptible to infection when inoculated with the same strain of virus. The sugarcane variety-virus strain combination, Co 285 and strain D, shows the recovery properties listed in the Introduction as follows: 1) permanence of recovery; 5) new infection upon inoculation; 6) negative assay for virus; 7) germination and foliage recovery; 8) adjoining buds with one recovered, one diseased; 9) lack of specific order of buds on stalk in relation to germination recovery; and 13) transient symptoms. of the other properties of recovered plants, none is contradicted by the results obtained here.

Two new facets of this disease-recovery relationship are brought out. First, hot-water treatment generally decreased the proportion which recovered, while increasing the rate of first appearance of

symptoms. Second, the first appearance of symptoms is gradual in time and variable in the number of leaves on the plant when it is first affected.

The effect of hot-water treatment on recovery is like that on inoculation. When setts of Co 312 were inoculated with sugarcane mosaic virus after heat-treatment, the rate at which symptoms appeared was increased, as was, in some experiments, the number of infected plants (3). By contrast, when setts of various sugarcane varieties were heat-cured from sugarcane mosaic, the number of diseased plants decreased; furthermore, the dosage of heat given in a single heat treatment that affects recovery or inoculation is totally inadequate to effect a heat cure among sugarcane-mosaic infected plants (4).

The conditions for early symptom development would seem to be satisfied in shoots from one-node cuttings of diseased stalks, as they obviously are in shoots from top cuttings. These conditions are that virus is present, virus movement is not blocked, and leaves capable of developing symptoms are available once the second or third oldest leaf with leaf blade has formed. However, in shoots from one-node cuttings, symptoms may be delayed for many weeks, the number of symptomless leaves may be large, and occasional plants may have only the axillaries diseased and not the main shoot, or vice versa, or may have only transient symptoms. A lack of susceptibility on the part of the plant would seem indicated. The occasional restriction of virus to one part of the plant suggests that the virus is not evenly distributed, but is localized in a region not favorable to its multiplication and movement. The role of heat-treatment in inoculated plants apparently is to increase the mobility of the virus and to favor the development of symptoms in young leaves (3), and the same role may apply in this system among the diseased progeny of diseased stalks.

The increase in the number of diseased shoots after heat-treatment of the cuttings (Table 2) shows that more cuttings contain virus than just those whose shoots become diseased when no heat-treatment is applied. It follows that, if heat-treatment is not applied, some of the recovered plants derive from virus-infected cuttings.

The two explanations of recovery discussed in the Introduction may be developed to include the results presented here. They would begin with one or the other of the following assumptions: 1) That in the growing shoot there is a probability that the subacute infection changes to an acute one. This probability may be conceived, for example, as the chance that one of a limited number of virus particles leaves the phloem among highly susceptible cells and establishes a focus of infection from which the plant can become diseased. The probability could increase with increases in the number of islands of highly susceptible cells, with increased virus movement, or with increased quantity of virus. 2) That the quantity of virus distributed among cuttings varies randomly, and that some cuttings contain little or no virus.

The increase in the number of plants with mosaic symptoms with time follows an S-shaped curve. It may be assumed that, both in the initial and final period, when the increase in the number of diseased plants is minimal, the capacity or susceptibility to develop symptoms is limited because the plants are too small or too large. During the middle period, the gradual increase in the number of diseased plants may reflect the probability that, independently in each plant, the infection changes from subacute to acute; the final proportion of diseased plants would be related to this probability. In those plants in which the infection remains subacute throughout the middle period, the virus would eventually be inactivated, and these would be the recovered plants. The probability that a subacute infection will become acute would vary among experiments, and heat-treatment would increase this probability. It would follow, from this interpretation of recovery, that the cuttings from which the recovered and diseased plants derive would be distributed at random on the stalk, because the plants that become diseased and those that recover would be selected by chance.

The random distribution along the stalk of cuttings that give rise to diseased and recovered plants may result from a chance variation of virus quantity within each cutting; some cuttings would have ample virus to become infected, while others, those that become recovered, would have too little to establish an infection normally. The effect of heat-treatment would be to increase susceptibility, so that quantities of virus otherwise too small to be likely to establish infection would, in heat-treated tissue, be sufficient. The gradual rate of symptom development could reflect the relative quantities of virus present in the cuttings.

These two views of recovery emphasize one or the other of the complementary components of an infection, the susceptible tissue or the infectious virus. As long as recovery is considered in relation to infection, a clear-cut choice between these views does not seem feasible.

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RATE OF PLANTING ON YIELD OF SUGARCANE INFECTED WITH MOSAIC

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ABSTRACT

Three tests were conducted using seed cane 100% infected with mosaic disease at rates of 2 stalks and 10% overlap and 3 stalks and 10% overlap. Similar disease-free checks were also included in the tests. Analysis of yield results showed that mosaic reduced the spring stand and final yields of L 60-25 in plant cane. Increasing the amount of seed significantly reduced this loss. A higher rate of either diseased or healthy seed did not increase first-ratoon yields of L 60-25. The germination and yield of the variety were not reduced by mosaic in the plant cane, although mosaic caused a significant loss at the lower rate of plant, but not at the higher rate, in the first ratoon. Increasing the rate of planting of L 60-25 is suggested if the cane to be used for seed is 100% infected with mosaic.

Editor's note: Only the Abstract of this paper was available for the Proceedings.

THE EFFECT OF FUNGAL ISOLATES FROM SUGARCANE ON SEEDPIECE GERMINATION

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ABSTRACT

Initial plant-cane stands of 5 sugarcane varieties were much better than plant-cane stands in later cycles. Pathogenic fungi were suspected as a cause of these poor stands. Ceratocystis adiposa, C. paradoxa, and Fusarium moniliforme were commonly isolated from the ungerminated seedpieces. Studies showed that 1) the 3 fungi could kill buds near the site of inoculation within 6 weeks, 2) C. adiposa and C. paradoxa were more pathogenic than F. moniliforme in the incubator experiment, and 3) C. adiposa and C. paradoxa, but not F. moniliforme, significantly reduced the shoot number of all tested varieties (C. paradoxa, of 6 varieties). Thus, adiposa and C. paradoxa may have contributed to the poor plant-cane stands in succession planting.

INTRODUCTION

Fungi have been implicated in the cause of poor stands of plant-cane in sugarcane fields in Louisiana. Among these fungi, Physalospora tucumanensis Speg. (Colletotrichum state) and Pythium arrhenomanes Drechs. have been most important (2), while Ceratocystis adiposa (Butl.) C. Moreau, C. paradoxa (Dade) C. Moreau, Gibberella moniliformis (Sheldon) Wineland (Fusarium state), and Phytophthora spp have been less important (2). However, Ceratocystis (2), and Phytophthora often caused severe rots of seedpieces in poorly drained areas where the soil remained wet and comparatively cold (8).

The effect of pathogenic fungi on cane stands may derive from 2 distinct modes of action: 1) attack on roots, thus indirectly affecting growth of developing shoots (Pythium spp.), 2) direct attack on seedpieces and buds (other fungi).

In a long-term variety yield-decline experiment at Houma, where land has been continuously cropped to the same variety of sugarcane since 1964, plant-cane stands were less dense in repeated plantings than in the first-cycle planting. Although poor land preparation played a part in the reduction in stand, fungal rot of seedpieces not a typical symptom of red rot caused by Colletotrichum was observed in the yield-decline experiment plot one month after planting.

Studies were undertaken to determine the fungal species in the ungerminated seedpieces, and to study the effect of some of these fungi on viability of buds under both controlled and field conditions.

MATERIALS AND METHODS

Nine samples of ungerminated seedpieces were taken from each plot of the long-term, yield-decline experiment in January and April 1972. The experiment, arranged in a randomized complete-block design, consisted of 5 replications of each of the following varieties: CP 44-101, CP 55-30, CP 52-68, CP 62-293, and NCo 310. Each plot was 3 rows, 18 x 75 ft, with 2-ft pathways. The soil was Sharkey clay.

Fungi were isolated from the seedpieces by a routine plating technique. Seedpieces, washed in tap water and then in 1% sodium hypochlorite solution, were aseptically split longitudinally into 2 halves. Four small pieces of tissue from each split seedpiece were transferred to each of 3 plates of potato dextrose agar (PDA), cornmeal agar, and oatmeal agar. All plates were kept at 25 C in the dark.

The work of Ellis (3), Gilman (4), Hunt (5), Rifai (6), and Toussoun and Nelson (9) were used to identify species of the fungi.

Inocula were prepared from 1- to 2-week-old cultures of the selected fungi on PDA. The surface of the culture was scraped lightly with a sterile scalpel into sterile distilled water. The spore suspensions were then passed through a layer of cheesecloth. Conidia concentration was determined by using a Levy Hemacytometer Chamber. The suspensions were then diluted to standard concentration of 800 to 1,200 spores/ml. The initial inocula used were isolated directly from the ungerminated seedpieces of the 5 varieties grown in the long-term yield-decline experimental plot. To maintain pathogenicity of Ceratocystis and Fusarium, these fungi were inoculated into seedpieces. Then they were reisolated from seedpieces and used for subsequent inoculation.

The stalk-puncture method (1) was used to inoculate the sugarcane stalks or seedpieces. Holes were punched in the middle of two internodes, and each was filled with inoculum (0.2 to 0.3 ml). Each seedpiece was inoculated with one fungus only. Control seedpieces were inoculated with sterile distilled water.

The effect of *C. adiposa*, *C. paradoxa*, and *F. moniliforme* (Sheldon) on viability of buds on seedpieces of 6 varieties of sugarcane (CP 52-68, CP 61-37, CP 65-357, L 60-25, L 62-96, and L 65-69), incubated at 15 C and 95-100 RH, was studied. The varieties CP 65-357 and L 65-69 were tested once, using field-grown mature cane, but the other varieties were tested 3 times with field-grown and greenhouse-grown mature canes. Seedpieces were obtained from plants showing no symptoms of sugarcane mosaic virus or ratoon-stunting disease.

Only the internodes between the third and fourth, and between the tenth and eleventh nodes from the base of undamaged stalks (each stalk with 14 to 14 nodes) were inoculated with one of the 3 fungi. The inoculated seedpieces were tied in bundles and incubated for 6 weeks in darkness. The viability of buds was then determined by direct examination. The hard or solid buds were classified as viable, and the water-soaked or soft buds as dead. Germination tests were made of the buds not easily placed in the viable or dead categories; one-node setts were planted in soil and kept in the greenhouse for 3 weeks.

The effect of *C. adiposa*, *C. paradoxa*, *F. moniliforme*, *F. solani* (Mart.) Appel & Wr., and *T. viride* Pers. ex Gray aggr. on germination of seedpieces of 7 sugarcane varieties was determined under field conditions. The stalks were selected from plants showing no symptoms of sugarcane mosaic or ratoon stunting disease. The 7 varieties were CP 44-101, CP 52-68, CP 55-30, CP 61-37, NCo 310, L 60-25, and L 62-96. The variety L 62-96 was obtained from Southdown Plantation, Southdown Land Co., in Houma, and the other varieties were from the Houma Station.

A factorial design was applied to test the effect of the 5 fungi on the germination of the 7 varieties in the field. Each treatment had 5 replicated plots, and each plot consisted of a single 22-ft row. Seven inoculated seedpieces with a total of 60 viable buds were planted in each plot on September 15, 1972. The soil was Mhoon silt loam. The plot, planted previously with soybeans, was well prepared before planting. The germination was expressed as plant shoots per plot. Significant differences between means were determined by Tukey's procedure (7).

RESULTS AND DISCUSSION

Isolation and Identification of Fungi.

Among the fungi frequently isolated from the ungerminated seedpieces of 5 varieties in January and April were *Ceratocystis adiposa*, *C. paradoxa*, *Fusarium moniliforme*, *F. solani*, *Trichoderma viride*, *T. harzianum* Rifai aggr., *T. koningii* Oud. aggr., and *Penicillium* spp. The following fungi were isolated less frequently from the seedpieces of the 5 varieties: *Cladosporium chlorocephalum* (Fresen) Mason & Ellis, *Humicola fuscoatra* Traaen, *H. grisea* Traaen, *Fusarium roseum* [Lk.] Fr., *Myrothecium roridum* [Tode] Fr., *M. verrucaria* (Alb. & Schw.) Ditm. ex Fr. and *M. striatisporum* Preston. *Colletotrichum falcatum* Went was isolated only from seedpieces of varieties CP 44-101 and NCo 310. *Phytophthora* was not isolated.

The infrequent isolation of *Colletotrichum* and the absence of *Phytophthora* from seedpieces might be caused by the resistance of the 5 varieties to the pathogens, or by unfavorable weather conditions for fungal growth in the seedpieces during and after the period of planting.

Effect of Three Fungi on Viability of Seedpieces Under Controlled Conditions.

Seedpieces of sugarcane, inoculated with or without *C. adiposa*, *C. paradoxa*, or *F. moniliforme*, did not germinate in the 15 C incubator in 6 weeks. It was possible, therefore, to determine the effect of the 3 fungi on the viability of ungerminated buds. The buds on nodes adjoining the inoculated internode were counted as tested buds. The total number of tested buds and the number of dead buds for each treatment are shown in Table 1. The 3 fungi killed buds near the site of inoculation in 6 weeks. *Ceratocystis adiposa* and *C. paradoxa* killed a greater number of buds on seedpieces of all tested varieties than *Fusarium moniliforme*. *F. moniliforme* killed buds on seedpieces of 4 varieties.

Table 1. Effect of 3 fungi on viability of buds expressed as percent survival on seedpieces of 6 varieties of sugarcane incubated at 15 C and 96-100% RH for 6 weeks.

Varieties	No. buds tested	Control	Fungi		
			<u>Ceratocystis adiposa</u>	<u>Ceratocystis paradoxa</u>	<u>Fusarium moniliforme</u>
CP 52-68	60	84	50	53	85
CP 61-37	60	93	42	50	83
CP 65-357 ^{1/}	24	87	54	58	79
L 60-25	60	93	55	70	92
L 62-96	60	83	50	60	72
L 65-69	24	92	58	62	83

^{1/} Data from one experiment only. Other varieties represent data from 3 experiments.

Data not included in Table 1 suggested that the susceptibility of the internode at the basal region of mature seedpieces was similar to that at the top. Whether the 3 fungi would attack the upper part of young seedpieces more severely than the lower part, or young seedpieces more than old seedpieces, needs further study.

Effect of Five Fungi on Field Germination of Seedpieces.

The shoot numbers of 7 varieties counted in November 1972 and April 1973, 8 and 31 weeks after planting, respectively, are shown in Table 2. The statistically significant difference at the 5% level of probability between any 2 means is 19.02 for the fall data and 17.45 for the spring data. Ceratocystis adiposa significantly reduced the shoot numbers of all 7 varieties below that of their respective controls. C. paradoxa significantly reduced shoot numbers of 3 varieties in the fall and of 6 varieties in the spring. The effect of C. adiposa and C. paradoxa on the shoot number of all varieties was most pronounced after freezing. Fusarium moniliforme and T. viride significantly reduced the shoot number of only one variety, L 60-25, in the spring, but not in the previous fall. Fusarium solani did not reduce the shoot number of any varieties significantly.

Table 2. Effect of 5 fungi on shoot number of 7 varieties of sugarcane in the field during the fall (F) and the following spring (S).

Inoculum	Variety							
	CP 44-101		CP 52-68		CP 55-30		CP 61-37	
	F	S	F	S	F	S	F	S
Water (control)	62.2 ^{1/}	22.2	47.2	31.8	48.4	26.8	53.8	31.0
<u>Ceratocystis adiposa</u>	30.2	3.0	26.0	6.6	23.6	0	16.6	3.0
<u>C. paradoxa</u>	28.4	1.0	31.2	8.2	29.6	4.0	28.2	2.2
<u>Fusarium moniliforme</u>	49.2	23.4	48.6	24.0	42.0	26.6	49.6	32.0
<u>F. solani</u>	45.0	23.8	51.8	29.8	45.2	29.2	45.2	33.2
<u>Trichoderma viride</u>	53.2	28.6	47.8	29.2	55.2	23.8	44.0	29.8

^{1/} Differences between means are significant at the 5% level (Tukey's procedure) if they exceed 19.02 for fall data (F) and 17.45 for spring data (S).

Inoculum	Variety					
	NCo 310		L 60-25		L 62-96	
	F	S	F	S	F	S
Water (control)	30.6	24.0	53.6	74.4	43.4	19.3
<u>Ceratocystis adiposa</u>	8.0	0.4	9.8	5.2	20.0	1.4
<u>C. paradoxa</u>	5.2	2.8	42.2	36.0	33.8	4.4
<u>Fusarium moniliforme</u>	27.0	21.6	41.6	38.2	27.2	14.8
<u>F. solani</u>	30.6	25.0	59.6	59.4	35.8	22.0
<u>Trichoderma viride</u>	27.0	23.0	50.0	51.6	44.2	23.2

The field data agree with the incubator data on the detrimental effect of C. adiposa and C. paradoxa. Fusarium moniliforme was less pathogenic in the incubator experiment, but it was not significantly different from the control in the field experiment.

The interaction between isolates of fungi and varieties of sugarcane was significant. The significant interaction indicates that the differences in the pathogenicity among the fungi are not the same for the 7 varieties.

C. adiposa and C. paradoxa in seedpieces killed buds near the site of inoculation in 6 weeks under cool and humid conditions and also significantly reduced the shoot number of seedpieces planted in a well-prepared silt loam. C. adiposa alone also reduced the number of tillers of stubble cane (10). C. adiposa and C. paradoxa, therefore, may have contributed to poor plant-cane and stubble-cane stands in succession plantings.

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EVALUATION OF SUGARCANE (SACCHARUM SP.) SELECTIONS FOR EYE SPOT RESISTANCE

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ABSTRACT

A total of 5,486 sugarcane selections were screened for resistance to the eye spot fungus, Helminthosporium sacchari. Ratings of progenies indicated that C1 59-1332, CP 66-1079, CP 56-63, and CP 63-588 transmitted eye spot resistance in higher frequencies than other clones. Resistant clones were obtained from all crosses, but their frequency varied widely among progenies. Of the total number of clones, 10.4% were resistant, 35.0% were intermediate, and 54.6% were too susceptible to be grown as commercial varieties. Progenies of many agronomically desirable parents contained a low percentage of eye spot-resistant clones. Therefore, a screening technique for eye spot resistance should be applied in the early stages of selection to eliminate the large numbers of susceptible clones.

INTRODUCTION

Eye spot sugarcane, caused by Helminthosporium sacchari (B. de Haan) Butler, was important during the development of the sugarcane industry in Florida because susceptible noble varieties were being grown (1, 4). There was very little problem with eye spot after breeding programs were begun and resistant varieties were released to the industry. The variety, C1 41-223, which has occupied a major portion of the Florida industry for many years, is very resistant to eye spot (1). In recent years with the release of a susceptible variety, CP 57-603, eye spot inoculum has built up drastically, and again it is important that commercial varieties be resistant to eye spot.

Steiner and Byther (5, 6) isolated a host-specific toxin from H. sacchari on sugarcane. When they sprayed young seedlings with partially purified toxin to screen for eye spot resistance, they found increased frequency of eye spot resistant clones in the surviving population (2). In the nontreated population, 15% of the adult plants were resistant, and 70% were susceptible. However, after seedlings of the same cross had been treated with the toxin, 50% of the surviving adult plants were resistant, and 14% were susceptible.

This study was conducted to evaluate selections in the sugarcane variety development program at Canal Point for eye spot resistance and to determine which breeding clones transmit eye spot resistance to a high percentage of their progeny.

MATERIALS AND METHODS

The clones inoculated in this study were Stage I selections in the regular breeding program. They included 5,486 clones from 75 different crosses and the commercial check, CP 63-588. Plots (2m x 2m) were planted in September 1972. The clones were inoculated with the eye spot fungus in Dec., 1972 and rated during the first week of Feb., 1973. Details of culture of the fungus and inoculation have been presented by Dean (3).

Clones were rated on a scale from 1 to 6. Ratings 1 and 2 represented resistant classes, which were more resistant than the commercial check, CP 63-588. Clones rated 3 and 4 probably had enough resistance to be grown commercially. Clones rated 5 and 6 were judged too susceptible to be grown commercially. A rating of 6 indicated that the clones were dead or very severely affected.

RESULTS AND DISCUSSIONS

Average progeny ratings for 49 crosses are presented in Table 1. The average rating of progeny within a cross ranged from a low of 2.10 for progeny of the cross C1 59-1332 x CP 56-63 to a high of 5.46 for progeny of the cross CP 68-1154 x CP 68-1022. C1 59-1332 transmitted eye spot resistance to a high percentage of its progeny in 2 other crosses. Average ratings for those progenies were 1.80 (data not shown) and 2.14 (Table 1).

Table 1. Mean rating scores of progenies of 49 sugarcane crosses screened for resistance to eye spot.

Female parent	Male parent							Mean of crosses
	C1 54-1910	CP 56-63	CP 56-59	CP 59-50	CP 63-306	CP 63-588	CP 68-1022	
C1 59-1332	*	2.10	3.00	3.00	3.96	2.14	3.86	3.10
CP 52-68	4.34	*	*	5.31	*	4.44	*	4.64
CP 59-50	3.78	*	*	*	*	3.12	4.24	3.48
CP 62-374	4.71	*	4.66	*	4.85	4.85	5.15	4.93
CP 63-306	*	4.09	3.67	*	*	*	3.45	3.86
CP 63-588	*	3.60	4.18	4.00	*	*	4.47	4.10
CP 65-357	5.05	4.01	4.40	4.07	*	4.31	4.75	4.50
CP 66-1043	*	3.29	4.78	*	*	3.50	*	3.64
CP 66-1079	*	2.39	*	3.24	*	2.39	4.10	2.93
CP 67-2004	4.11	*	*	*	4.56	*	4.90	4.65
CP 68-1145	2.52	4.50	*	4.41	*	3.90	*	3.97
CP 68-1154	5.15	*	*	5.18	5.11	4.46	5.46	4.95
Mean of crosses	4.66	3.79	4.34	4.19	4.66	3.90	4.78	

* This cross was not evaluated.

CP 66-1079 also transmitted resistance and was the female parent in the crosses that had the 4th and 5th lowest average eye spot ratings (2.39 each). Because of the difficulty in obtaining seed from C1 59-1332 and CP 66-1079, small numbers of progenies were involved in most of their crosses. Several clones that have adequate resistance to eye spot under field conditions in Florida produced progenies that were very susceptible to eye spot, as shown by the high average progeny means in Table 1. Of the 16 clones listed in Table 1, eye spot is a problem only on CP 68-1154 in fields of mature sugarcane. As might be expected, progeny of CP 68-1154 had the highest mean eye spot rating (4.95) of any clone in this study. Progeny of CP 62-374 had the second highest mean rating (4.93), indicating that, even though eye spot is not a problem in commercial fields of CP 62-374, most of its progeny are susceptible. Of clones used as male parents, CP 56-63 and CP 63-588 had the highest percentage of resistant progenies. Progenies of CP 68-1022, CP 63-306, and C1 54-1910 had the highest mean eye spot ratings (4.78 to 4.66) of clones used as male parents, but the cross CP 63-306 x CP 68-1022 had the lowest average eye spot rating (3.45) of all crosses with either parent.

The mean eye spot rating for progeny of the most susceptible and most resistant crosses and the mean of progenies of at least 7 crosses with each 7 male clones are presented in Fig. 1. Progeny of at least 1 cross with C1 54-1910, CP 56-63, and CP 63-588 contained a high percentage of clones with adequate eye spot resistance. The means across all progenies of CP 56-63 and CP 63-588 were considerably lower than for C1 54-1910. This indicated that CP 56-63 and CP 63-588 transmitted resistance to a high percentage of their progeny when crossed to a number of parent clones, i.e. they had good general combining ability for eye spot resistance. In contrast, C1 54-1910 gave a high frequency of resistant progeny when crossed with only 1 clone; thus C1 54-1910 exhibited specific combining ability for eye spot resistance.

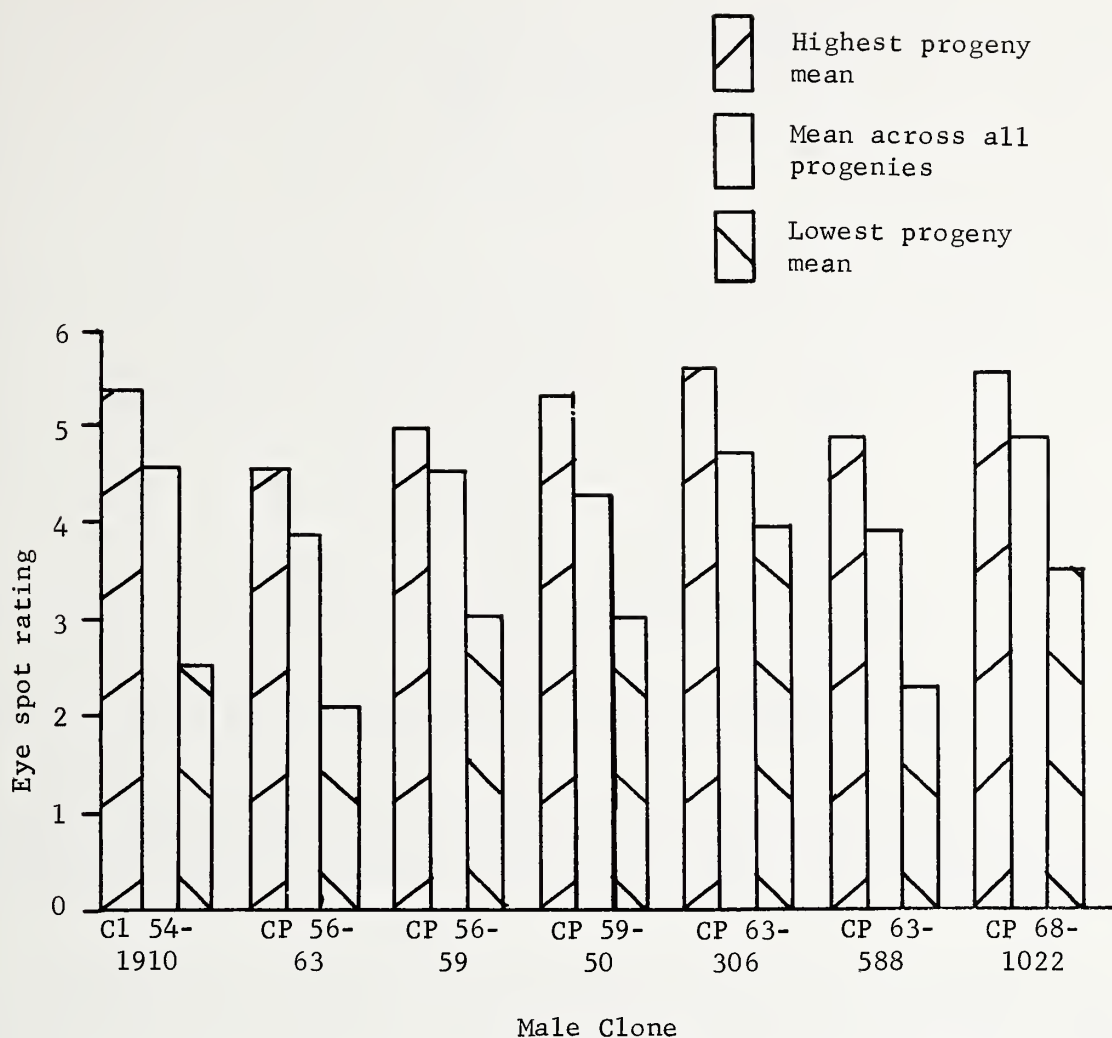


Fig. 1. The highest progeny mean, the mean across all progenies, and the lowest progeny mean eye spot rating for at least 7 crosses with each of 7 clones used as male parents.

The key to success in a breeding program is not the average performance of the progeny of a cross, but is the performance of the best individual clones. Table 2 shows the distribution of clones in each eye spot rating class and the total number of clones in a progeny when CP 63-588, a resistant variety, was used as the male parent. The cross with C1 59-1332 had the highest frequency of resistant clones, followed closely by the cross with CP 66-1079. The cross with CP 68-1154, a susceptible clone, produced a low percentage of resistant progeny.

Table 2. The distribution as percent of the progeny in each eye spot rating class for 9 crosses with CP 63-5-8 (a resistant clone) as the male parent.

Female parent	Eye spot rating classes						Number of clones rated
	1	2	3	4	5	6	
C1 59-1332	29.7	43.2	13.5	10.8	2.7	0	37
CP 52-68	3.0	6.1	10.1	21.2	43.4	16.2	99
CP 59-50	5.0	23.0	38.0	23.0	11.0	0	100
CP 62-374	0	0	15.4	23.1	23.1	28.5	13
CP 65-357	5.9	6.6	9.2	23.7	38.2	16.4	152
CP 66-1043	4.8	16.1	25.8	33.9	16.1	3.2	62
CP 66-1079	38.9	27.8	5.6	16.7	5.6	5.6	18
CP 68-1145	10.4	9.6	14.8	25.2	24.4	15.6	135
CP 68-1154	0.8	5.5	7.1	31.5	44.1	11.0	127

The distribution by eye spot rating class of progeny of crosses in which CP 68-1022 was the male parent is shown in Table 3. Progeny of Cl 59-1332 x CP 63-588 had the best eye spot resistance of any progeny with CP 63-588 as the male parent. Progeny of Cl 59-1332 x CP 68-1022 has the second highest frequency of eye spot resistance of any progeny with CP 68-1022 as the male parent. The cross CP 63-306 x CP 68-1022 is surprising in that it had the highest frequency of resistant progeny of all crosses with CP 68-1022, while the average eye spot ratings of all progenies of both parents are quite high. Progeny of other clones in this study, Cl 59-1332, CP 56-63, CP 63-588, and CP 66-1079, which have given good resistance in other crosses, all had lower frequencies of resistant types than CP 63-306. This indicates that the combination CP 63-306 x CP 68-1022 gives specific combining ability for resistance. Even in some of the most susceptible progenies, for example, CP 62-374 x CP 68-1022, resistant types occur, though at very low frequencies.

Table 3. The distribution as percent of the progeny in each eye spot rating class for 12 crosses with CP 68-1022 (an apparently resistant clone) as the male parent.

Female parent	Eye spot rating classes						Number of clones rated
	1	2	3	4	5	6	
Cl 59-1332	5.6	5.6	27.8	27.8	25.0	8.3	36
CP 56-59	0	0	0	20.5	41.0	38.5	39
CP 56-63	0	0	0	5.0	35.0	60.0	40
CP 59-50	0	2.9	29.4	26.5	23.5	17.6	34
CP 62-374	0.3	0.3	6.0	13.6	37.2	42.6	331
CP 63-306	7.1	14.3	23.2	39.3	14.3	1.8	56
CP 63-588	1.4	1.4	8.2	35.6	45.2	8.2	73
CP 65-357	0	2.3	6.3	23.4	50.0	18.0	222
CP 66-1079	0	0	30.0	35.0	30.0	5.0	20
CP 67-2004	0	2.6	5.2	15.7	52.2	24.3	115
CP 68-1115	0	1.5	3.0	4.5	43.3	47.8	67
CP 68-1154	0	0	0	6.6	41.0	52.5	61

When the data were grouped into rating classes across all crosses, each rating class contained the following percentage of the population: class 1, 3.7; class 2, 6.7; class 3, 12.0; class 4, 23.0; class 5, 35.5; and class 6, 19.1. Therefore, 10.4% of the population was more resistant than the commercial check (rating classes 1 and 2), 35.0% of the population was intermediate in resistance (rating classes 3 and 4), and 54.6% of the population was too susceptible (rating classes 5 and 6) for commercial production.

Apparently there are not enough clones that transmit a high frequency of resistant progeny and also have other desirable agronomic characters to limit the crossing program to those clones. Therefore, it is necessary that we screen large numbers of selections for resistance to eye spot in early stages of selection to reduce the cost of handling susceptible clones in later stages of testing. By eliminating susceptible clones in early stages, we can apply more selection pressure for other characters in the later stages of the selection program.

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FROST VS. CANE JUICE ACIDITY - CANE SUPPLY LINE INSPECTION

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ABSTRACT

Due to freezes which occurred on Dec. 16, 1972, and thereafter, the cane in the field started to show signs of deterioration even as early as 3 days. It is understood that acidity may not be a good indicator to exactly measure the degree of deterioration of frozen cane, yet it serves a quick check of cane supply in order to safeguard and maintain normal factory operations before, not after, the cane is milled. A program is, therefore, worked out, and a team of inspectors formed. Each tractor and truck is inspected before it passes through the weighing scale. The inspection involves splitting of cane top sections for observing, smelling, and tasting samples of 5-10 stalks. For the acidity test, 10 stalks (full length) are withdrawn from each car-load and sent for immediate milling and testing, which should be done within a few minutes. Results obtained from such vigilance help guide the cane growers to make special efforts. The normal performance maintained at the mill confirms the accomplishment of such inspection.

The importance of cane juice acidity to sugar recovery has been reported by the authors during the ASSCT 1972 meeting. (1).

Due to freezes which occurred on Dec. 16, 1972, and thereafter in Louisiana, the cane in the field started to show signs of deterioration within 3 days. By splitting the cane stalks, some brown coloration could be clearly seen, especially at the apex of the growing point and in the top nodes.

A large truck load of 25 tons of cane may take 10-15 min to get through the milling tandem. If the sugarcane is badly deteriorated, it is enough to foul up the clarification and finally the crystallization stations. In order to safeguard and maintain normal factory operation before, NOT after, the cane is milled, 2 programs were devised and an inspection team was formed right after the first freeze.

One program was to evaluate the juice quality due to frosts and to work out the priority of harvest. The results of this program are to be presented in a separate paper at this meeting.

The other program was to inspect every truck and trailer of the incoming cane before it was weighed and accepted. The results of this program are presented in this paper. The targets set for such inspection were:

- 1) Acidity over 4.0: reject the load.
- 2) Acidity of 3.5: advise the driver to bring message to respective grower to adjust topping of the cane.

Suggestions by Lauden (2) were very helpful for the field-factory relationship under this adverse condition; however, it was found necessary to take positive action to assure millable cane supply, and to coordinate both parties so that neither was discouraged.

It took 4 persons at the inspection check-point 12 hr per day, doing splitting of cane stalks, tasting, and withdrawing samples and sending them for the acidity test. One person was required for the milling of juice, and another person for making the titration, making a total of 6 persons actively engaged in the program.

The inspection started daily from 6 am until 6 pm. It involved:

- 1) Picking out 5-10 stalks from each truck and trailer load.
- 2) Splitting each top section for observing, smelling and tasting.
- 3) Random samples of 10 stalks, full length, per car were withdrawn, and sent for an acidity test, which could be done within a few minutes.
- 4) Whenever the tasting indicated doubtful acceptability, a sample of 10 stalks was taken and sent for an acidity test. The car can be detained until the acidity figures are obtained.
- 5) The acidity level was continuously made known to the truck and trailer drivers to be reported to their respective growers, so that the growers may make timely adjustment in their harvest schedule and proper topping.
- 6) If any grower needed some guidance concerning the acidity on a particular field, he was encouraged to bring in a sample of 10 stalks for the acidity test before he actually harvested the field.

By comparing the size of sample between the routine normal juice quality test and our check-point sampling, it could be seen that a sample from the check-point should be more representative:

For normal-juice quality
test: 5 stalks/50-60 tons = 10 stalks/100 ton

For check-point sampling:
10 stalks/8 ton (trailer), 120 stalks/100 ton or
or 10 stalks/20 ton (truck) = 50 stalks/100 ton

The results obtained from the supply line inspection are compared with the routine normal-juice test in Table 1.

Table 1. Cane juice acidity.

Dates * (1972-73)	Supply line inspection samples				Routine normal juice test samples (daily ave. on wt. cane)
	No. car sampled	Daily average	High	Low	
Dec. 26	59	2.7	3.9	1.9	2.6
27	29	2.5	3.3	1.8	2.8
28	84	2.8	5.9	1.8	2.7
29	86	2.8	3.9	1.8	3.1
30	63	2.6	3.5	1.8	3.0
31	56	2.6	3.2	1.8	2.5
Jan 1	55	2.6	3.0	1.9	2.6
2	72	2.6	3.7	1.9	2.5
3	67	2.7	3.9	1.9	2.5
4	74	2.7	3.8	1.9	2.5
5	66	2.8	4.8	1.8	2.8
6	40	2.8	4.0	1.9	2.4
8	27	3.0	3.6	2.3	2.3

* Starting from the 10th day after the first freeze.

Results of such inspections, with cooperation of the cane growers, maintained the daily averages well below 3.0. However, growers with samples having high acidity, exceeding 3.5, were immediately informed. By closely supervising their harvest, this led to cane of much lower acidity. The factory operation was, meanwhile, checked closely during this period, and no significant difficulty was encountered after the freezes.

The samples brought in by growers for checking, before harvesting, helped to insure the success of the inspection program. Some special check samples showed acidity as high as 9.2, and many were in the range of 4.5 to 5.9. If it were not for such vigilance before harvesting and milling, possible detrimental effects may have occurred in the factory operation.

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EVALUATION OF POST-FREEZE CANE JUICE QUALITY .

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ABSTRACT

Previous reports on the effects of freezing on sugarcane are found in several publications. Acidity is one of the criteria most commonly used in evaluating cane juice quality by measurement of the degree of deterioration due to freezes. However, the limitations of acidity as a criterion of quality have been reported by previous investigators. In order to observe more closely the changing of cane quality in different aspects after freezes, it is necessary also to use other criteria. After several freezes had occurred on and after Dec. 16, 1972, cane samples from more than 20 locations were collected, starting Dec. 18, with 3 replications at each location, and with a frequency of once every other day until the end of the harvesting season. Each sample was analyzed for brix (refractometric), pol, clerget sucrose, invert, pH, acidity and stalk weight. The results obtained were used for various calculations. Comparisons have been made in relation to: time (days), ambient temperatures, cane variety, graduation from apex down, topped and untopped, burnt and unburnt, standing and lodged, cut and uncut, etc.

On Dec. 16, 1972, freezing temperatures as low as 26 F occurred at Houma. The freezing temperatures lasted for 9 hr and the minimum of 26 F lasted for 30 min.

Most fields of sugarcane were completely brown within a few days after the freeze. All terminal buds were found to be killed. The damage to lateral buds and stalk tissue varied with cane varieties and localities.

Below freezing temperatures occurred again during the period of Jan. 11-12, 1973. The below freezing temperatures lasted for 10 hr, and the minimum temperature reached was 23 F; this lasted for 60 min.

The post-freeze temperatures were relatively low, and the deterioration during the 25 days following the first freeze was not marked. However, deterioration following the second freeze was severe.

Previous reports on the effects of freezing on sugarcane can be found from several publications (2, 3, 4, 5, 6, 7). Titratable acidity is one of the criteria most commonly used to indicate degree of deterioration due frost, but the limitations of this criterion have been reported by previous investigators (6). In order to observe more closely the pattern of cane quality in different aspects after freezing, it is necessary also to use other quality criteria at the same time.

The period of investigation extended from Dec. 18, 1972 through Jan. 19, 1973. Cane samples were collected once every 2-3 days from 20 locations in the divisions of Southdowns, Inc at Houma, Thibodaux, and Vacherie. Data were collected from 3 replications at each location.

The number of samples was gradually diminished as the harvesting operations progressed; however, some new sampling locations were added from time to time.

The samples were handcut, topped at the last hard internode, and hand-milled without burning. On each sampling day, some 60 crushed juice samples were analyzed for stalk weight, brix (refractometric), pol, clerget sucrose, invert, pH and titratable acidity.

The results are shown in Fig. 1, 2 and 3.

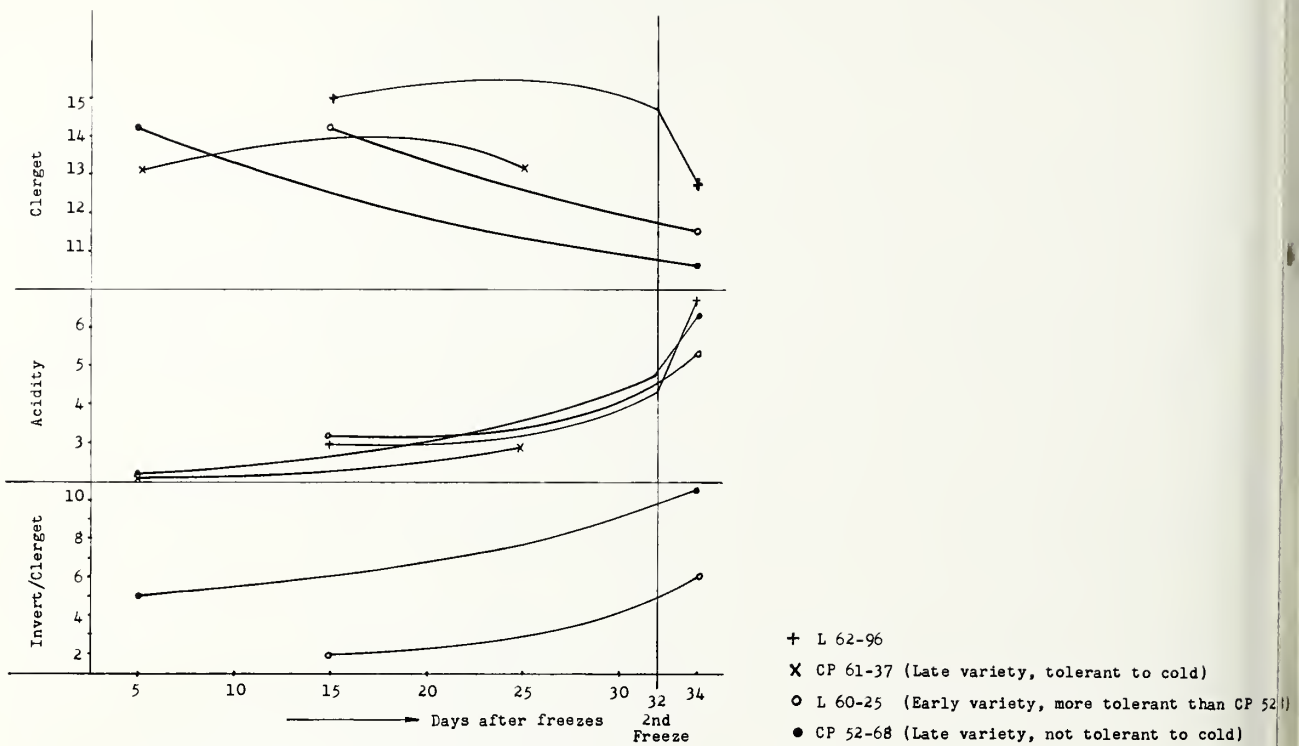


Fig. 1. Varietal difference in deterioration due freezes.

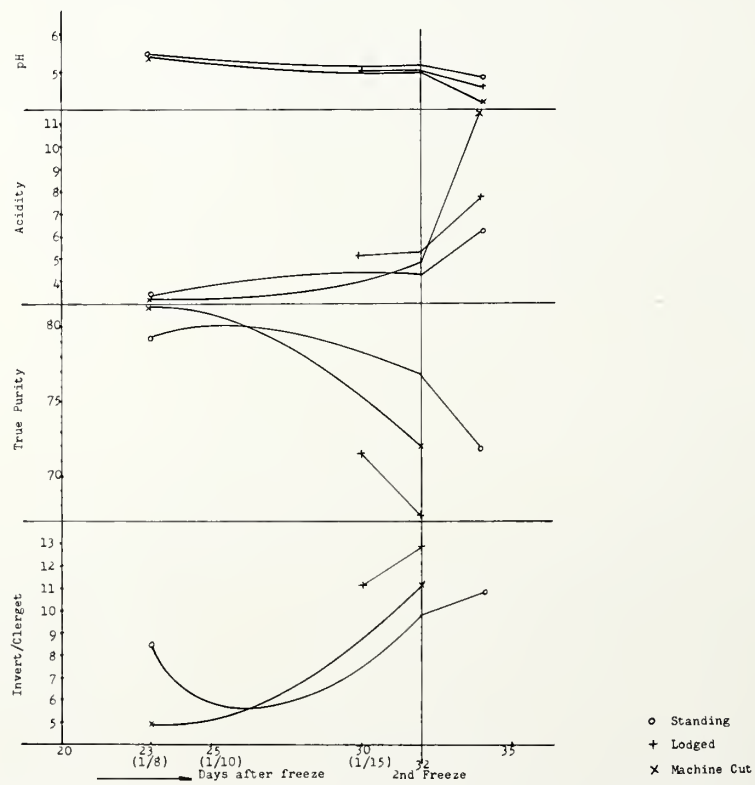


Fig. 2. Standing, machine cut and lodged (after freeze 12/16/72) (From Abby Plantation, CP 52-68, plant cane)

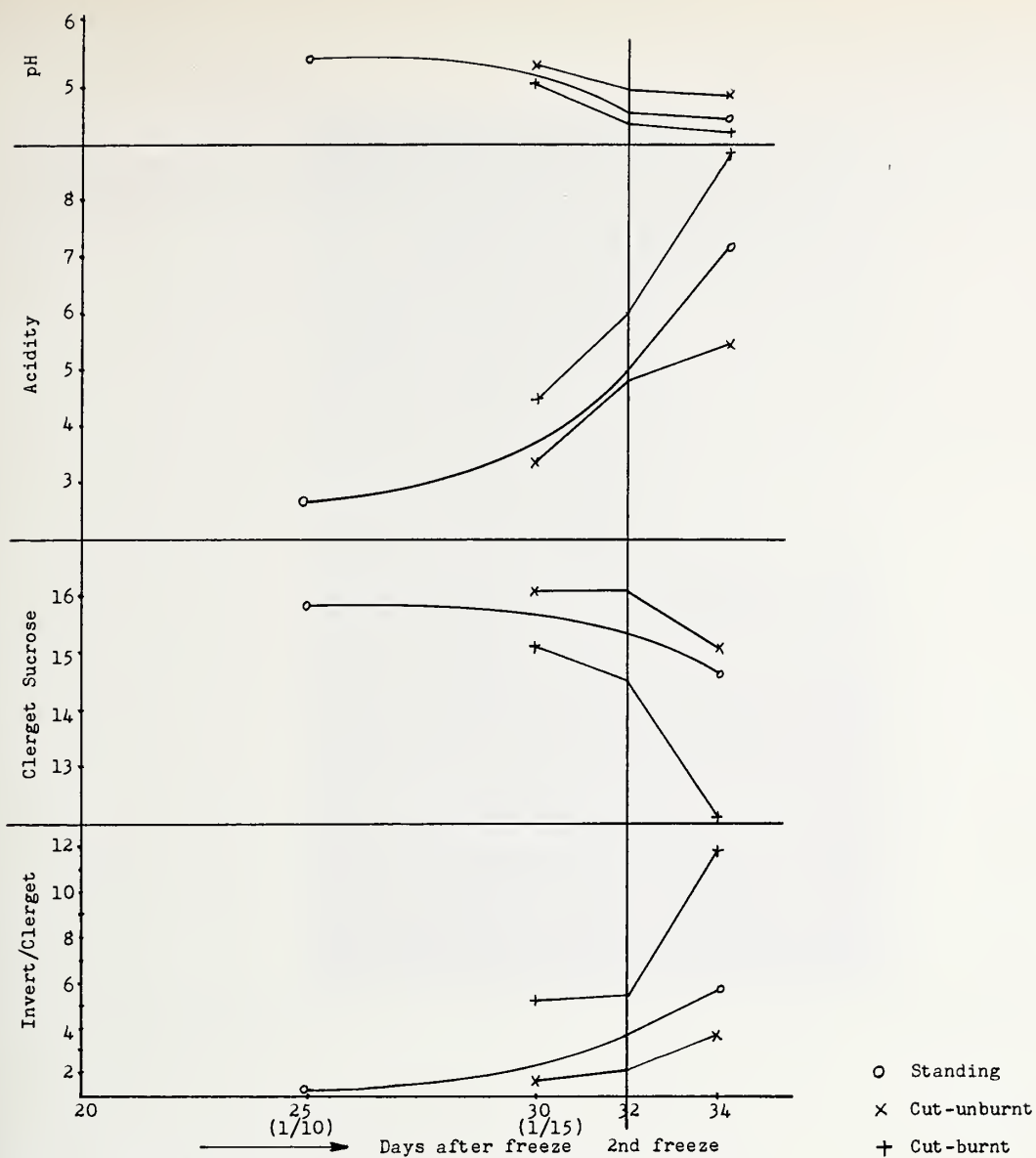


Fig. 3. Standing, cut-burnt and cut-unburnt (after freeze 12/16/72)
(From cut 6, Southdown Plantation, L 62-96, plant cane)

To further observe the starting point and affected area of deterioration, special samples of whole cane stalk were collected, and juice quality of different sections was determined. Photographs 1 and 2 show the difference between normal cane and deteriorated cane.



Photo 1. Growing Point (Normal Cane vs. Freeze Damaged Cane. The normal cane was provided from the greenhouse of the USDA Exp. Station).

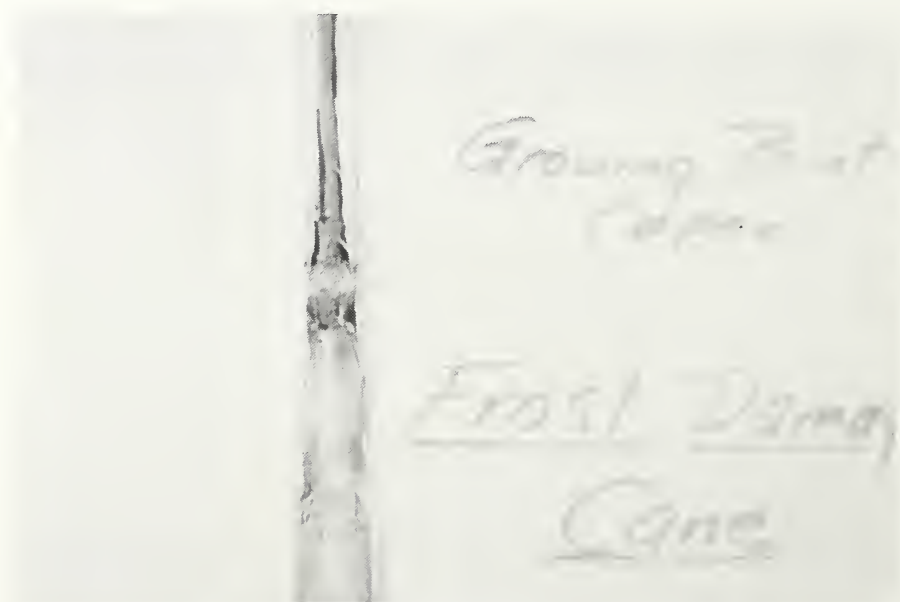


Photo 2. Close-up of the Apex of Freeze Damaged Cane.

The cane juice quality as related to and affected by the top portion of the stalk is shown in Fig. 4, 5, and 6.

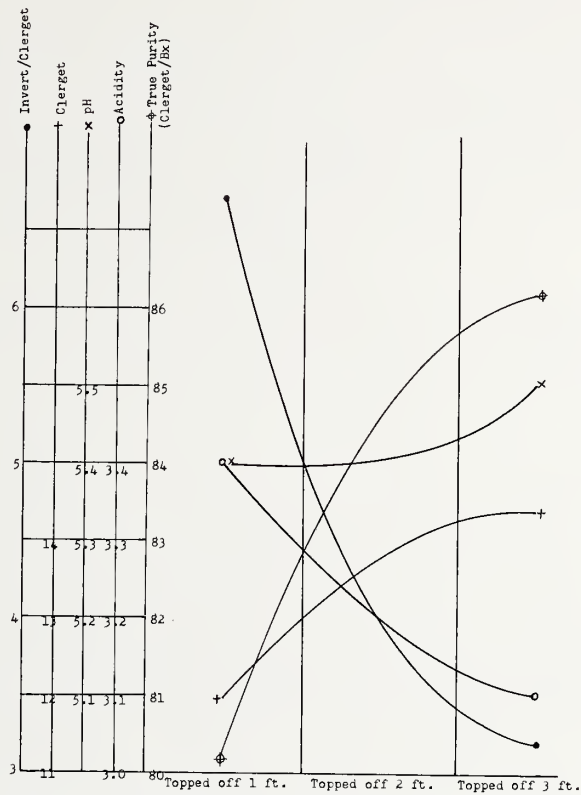


Fig. 4. Juice quality vs. length of topping.

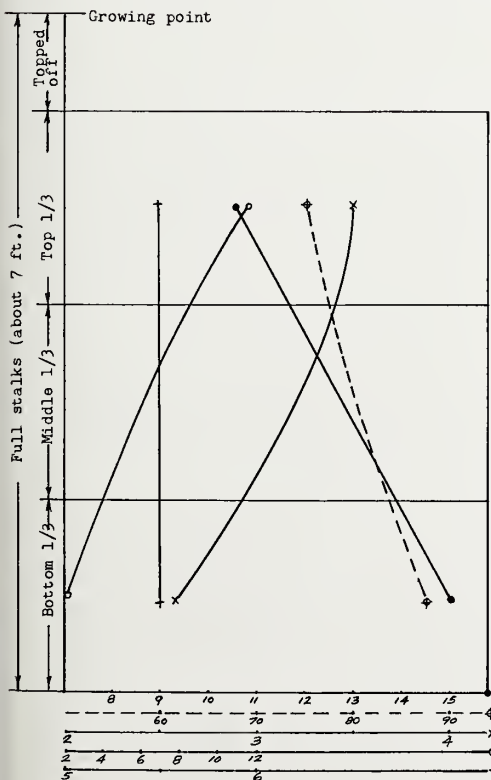


Fig. 5(a). Juice Quality vs Stalk Sections (18 days after freezes. Topped off 1 ft from Growing Point)

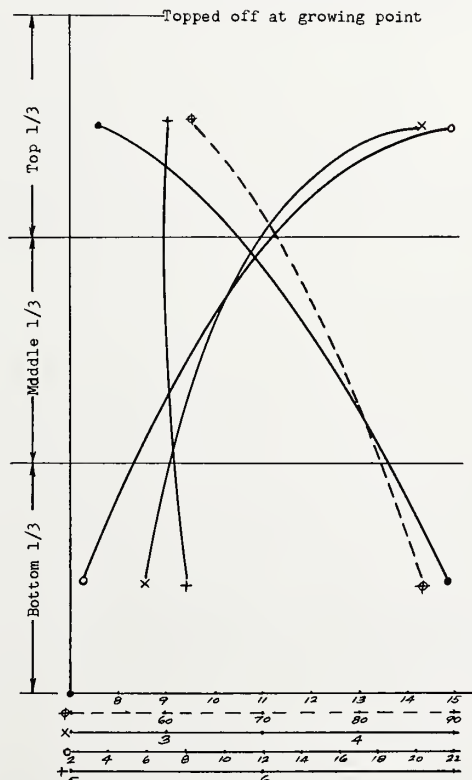


Fig. 5(b). Juice Quality vs Stalk Sections (20 days after freezes. Topped off at Growing Point)

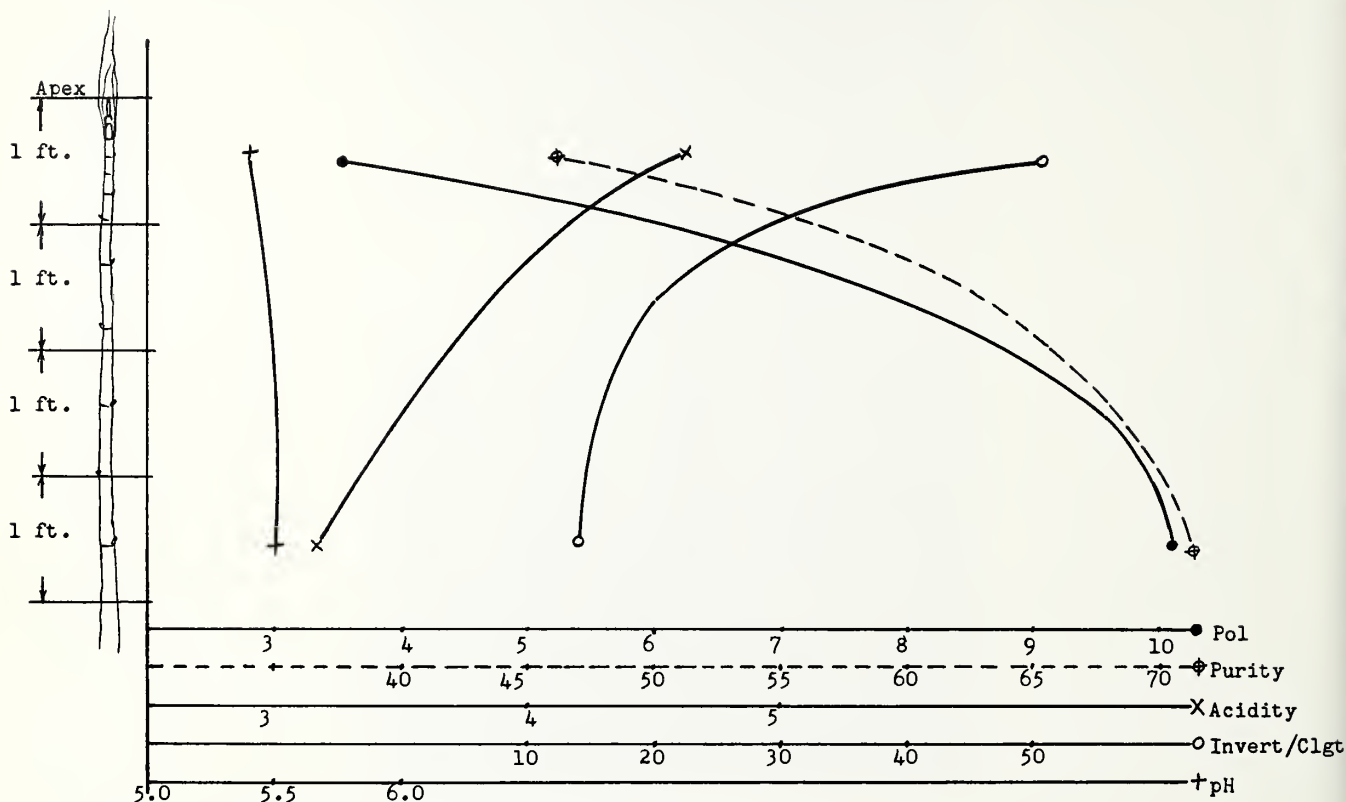


Fig. 6. Juice Quality of Top Portion of Cane after Freezes
(23 days after freeze of 12/16-17, 1972)

OBSERVATIONS AND IMPRESSIONS

1. The rate of deterioration is governed by the combination of three main factors: the freezing temperatures, the duration of the lowest freezing temperature, and the post-freeze temperatures.
2. Among cane varieties tested, CP 52-68 showed the greatest amount of tissue damage, followed by L 60-25 and L 62-96; CP 61-37 showed the least amount of damaged tissue and seemed to be more resistant to freezing. These field observations are confirmed by the quality test results.
3. It was already known that pH is not correlated with acidity. In measuring the deterioration of cane, pH is a very poor yardstick.
4. In the comparison of standing, lodged and machine-cut cane, there was more damage in the last two.
5. The comparison of standing, cut-unburnt and cut-burnt showed more rapid deterioration in the burnt cane. The relatively favorable quality in the unburnt cane is an indication that the cut, unburnt cane was presumably protected from severe freeze damage by being piled on the ground, whereas the standing cane was exposed more to the freeze, thus accelerating deterioration.
6. The quality of juice in the tops indicates the degree of decomposition and its effect on quality of the stalks. The quality curves turned sharply toward the apex.
7. The upper part of the stalk plays a very important negative role in sugarcane processing, especially after freezes. The increase in acidity in the top not only increases the processing costs, but also complicates normal operation and finally reduces sugar recovery, as demonstrated in previous field-factory case studies (1).

8. The increase of acidity is not necessarily associated with increase in the invert sucrose ratio because, while sucrose is being inverted, some inverts are being decomposed.
9. The decomposition products from cane deterioration are detrimental to cane juice clarification and also to the refining quality of raw sugar produced.
10. The results obtained in this investigation show that proper handling, especially proper topping, of cane after freezes not only is beneficial to the cane grower but is also essential for the cane processor to maintain normal operation and recovery.
11. The measurement of deterioration is yet to be established. Those detrimental decomposition products have to be first identified.

ACKNOWLEDGMENT

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SOLID STATE CONTROL FOR A SUGAR CENTRIFUGALS AT
GLADES SUGAR HOUSE

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Because of the expected large crop for 1972, considerable equipment was installed during the off-season last year, among which were 4 30 X 48 in. C sugar and 2 A sugar centrifugals.

The previous year, because of various problems with the conventional electro-mechanical sequencer for the A sugar centrifugal battery, we had designed and built in-house a solid state sequencer which eliminated all our problems and operated continuously during the 1971-72 and 72-73 crops without a single failure.

This reliable operation of the solid state sequencer induced the writers to recommend to management that at least some of the controllers for the 6 new centrifugals should be built using industrial type solid state logic cards, and after considerable discussion of the subject it was decided to use solid state control on the 2 A sugar centrifugals and conventional relay controllers on the 4 C sugar centrifugals.

In order to keep the manufacturer's guarantee and responsibility it was decided to let our centrifugal's supplier provide the solid state controller using the same line of logic modules as we had incorporated in our sequencer since our electricians had already become familiar with them, thus making initial debugging and future trouble-shooting easier.

The 2 individual controllers are housed in a 22 X 22 X 8 in. metal box. This compares favorably with the 30 X 74 in. panel required per machine for the conventional relay controller.

This large reduction in space requirement makes it possible to use a small centrifugals control room, less air conditioning and lighting load.

These controllers were installed and debugged in a few days and put in service at the start of last year's grinding season and they operated continuously without a single failure throughout the season.

The solid state controllers have some advantages over the conventional relay controllers, some of which are:

1. Logic voltage is 0-5V DC.
2. Logic power requirement is approximately 7 watts.
3. Neon lights or light emitting diodes on all input and output signal terminals.
4. Interchangeable standard plug-in logic cards.
5. Moisture resistant.
6. Non-oxidizing parts.
7. No moving parts.
8. Small space required.

The usual process for converting a relay logic control circuit to a solid state controller is to convert the ladder diagram, rung by rung, to digital logic elements and then select the necessary logic cards that will make up for all the digital elements required by the controller and wire them to conform with the connections shown on the logic diagram.

This is exactly what was done in the case of our two A centrifugal controllers, thus assuring a one to one circuit translation.

The operating personnel at Glades Sugar House is satisfied with the high reliability, no down time or maintenance so far obtained from these 2 centrifugal controllers and is recommending the change to solid state of 5 more centrifugals next year and, from now on, that any new units to be added be solid state.

SOLID STATE CENTRIFUGALS BATTERY SEQUENCER AT GLADES SUGAR HOUSE

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ABSTRACT

Electrical problems normally caused by malfunction of electromechanical centrifugals battery sequencers have been eliminated by substitution for the stepper sequencer with a locally-built solid-state scanner which performs the function of the stepper and controls auto dilution. Installed for the 1971-72 crop, the unit has been operating without any maintenance or a single failure. In this paper the authors discuss the simplicity of their design and present a block diagram for its implementation.

Prior to the 1971 grinding season, Glades Sugar House was having trouble with the operation of the electromechanical battery sequencers on the A and C centrifugals.

Burnt out or frozen contacts on the stepper switch and delay time variations of the timing relay caused by increasing residual magnetism as time went by accounted for the greatest part of the sequencer's off time.

Malfunction of the stepper ratchet and rectifier also was responsible for sequencer's off time.

When the A sugar centrifugal battery sequencer became inoperative, the operator would change to the recycle mode; but this mode of operation has its drawbacks, too, since slight variations of process timer settings, difference in sugar consistency along the mixer axis and different response time of the various centrifugal mechanical components make a preset discharge sequence uncertain.

Therefore, when the battery is operated in the recycle mode for extended periods of time, it is hard for the operator to keep the sugar discharging in the correct sequence to prevent spilling.

In the case of the Glades Sugar House when the electromechanical sequencer went out of service and the battery was operated in recycle (with the inevitable use of manual operation occasionally), two or more centrifugals would discharge at the same time or very close to each other, causing sugar to spill out from the grasshopper conveyor and overloading the inclined belt and bucket elevator. This, of course, resulted in the spilling of sugar to the floor and considerable lost time.

To get maximum production from a centrifugal battery it must be operated using a dependable and reliable sequencer. This is why we were prompted to design a digital solid-state sequencer to replace the electromechanical device.

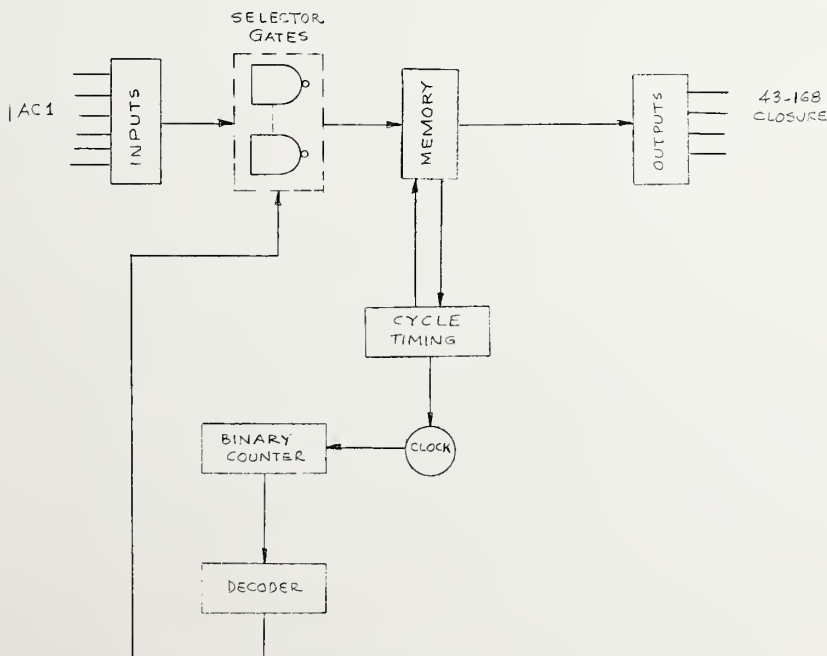


Fig. 1. Block diagram of solid-state sequencer.

The solid-state sequencer was built and installed during the 1971 dead season and put to test in that year's grinding period. It performed so well that there was not a single outage during the crop.

For the last year's crop, management requested that we build another unit for the C centrifugals. This time we incorporated autodilution for magma and molasses for the C centrifugals battery and for molasses on the A centrifugals battery. Again the performance of both units was perfect during the past grinding season.

The sequencer consists of an input module which conditions the centrifugal's input signals and changes them to logic levels of 0 and 5 volts DC; a group of gates, which in combination with a scanner section, allows sequential signals to be stored in memory for the required period of time; an on delay timer which is adjusted for the required cycle time, a clock and scanner section made out of an astable multivibrator, binary counter and decoder and an output module to convert logic signals back to 120 V AC.

The counter can be programmed for any modulo N counting, N being equal to the number of centrifugals in the battery.

All modules used are of the industrial type, noise free and are pluggable and easily removable.

The molasses and magma dilution control units are implemented by single shot multivibrators with variable time control.

Although the description of the sequencer may sound a little complicated, it is in fact very simple to understand and to trouble-shoot when and if this becomes necessary.

The electricians at Glades Sugar House find that it is much easier and simpler to go through its logical circuitry than it is to follow the conventional electrical ladder diagrams.

AUTOMATION

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Belle Glade, Florida

Automation has always meant to us more than a mere aspect of wage-saving. This, of course, has its proper place in the business management of any industry; but we believe that the greatest pay-off in automation lies in efficiency. This efficiency is achieved through the use of instruments that can reach inaccessible places, and operate under conditions which are unfavorable to the unaided human senses.

The use of automation in the sugar industry began a long time ago, but it was generally restricted to cases where mechanical sophistication resulted in elimination of human labor at one step or another.

With some exceptions, this aspect of efficiency through automation has been rather neglected.

We have had the good fortune to work for a progressive firm that shows great enthusiasm for modern trends and is confident of the profits to be derived from the overall benefits of a better operation and a better efficiency.

Today the sugar industry is forced, more than ever before, to become fully involved in automation; not only because the need to use less personnel has arisen, but also because we are running short of skillful manpower that must be substituted for at one time or another by men that do not have the necessary skills. At the same time, making the work easier and more attractive to those men that are still available has become a must.

The so called push-button operated factory has been a dream of the sugar technologists for a long time, but today it is no longer a dream, but a necessity.

We have used and are using automation in some particular steps of the process of grinding sugarcane and making cane sugar where automation is not commonly used, and it is this particular case of automation that we are bringing to your attention in this paper.

GRINDING OPERATIONS

Automation of the Cane Conveyers: The automation of our grinding plant starts right in the auxiliary conveyers that supply the main cane carrier. We have cane height sensing devices controlling the speed of the conveyers in such a way that they deliver to the main cane carrier a proportional amount of cane so as to have a cane height as even as possible, easing in this manner the work of our cane knives.

Automation of the Mills: The first mill is set at a certain fixed speed according to the grinding rate desired. From this point on our second sensing device controls the speed of the main cane carrier that feeds the mill tandem with a constant, steady and uniform volume of cane.

In the rest of the mills, we use the same cane or bagasse blanket height sensing devices and pneumatic instruments, controlling the speed of the turbines and the intermediate conveyors, maintaining a uniform and steady thickness of the bagasse blanket being fed to the mills.

In this way, we assure a constant floating of the top roll at all times, which results in a reduction of the possibility of chokes, less slippage, easier operation, better extraction, and less attention from the mill foreman, who has more time at his disposal to look and check the other facets of the operation and equipment.

The elements of the control are depicted in Fig. 1, and are as follows:

1. One cane height sensing device.
2. Two motion transmitters, one for transmitting the height of the bagasse blanket, the other to indicate the lift of the top roll.
3. One amplifying relay 1 to 4 to transmit, multiplied by 4, the 3-15 psig output from the pneumatic control to the turbine governor.
4. One high pressure selector switch to facilitate the change from manual to automatic, or vice versa, and a safety device to insure a certain minimum speed of the mill in case of pneumatic failure.

5. A pneumatic recording controller with two pens; one (red) controls the height of the cane, and the other one (blue) records only the top roll lift.

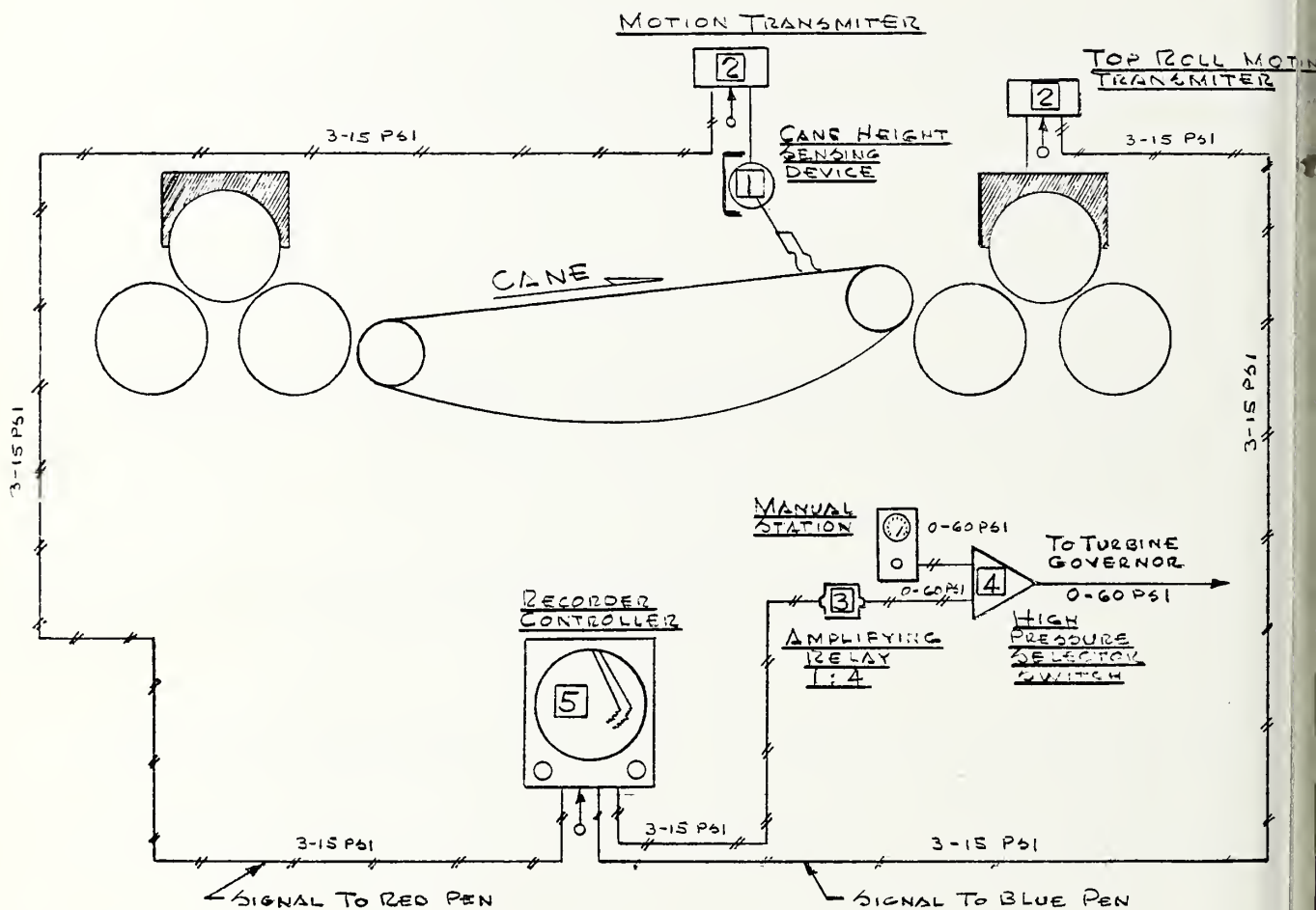


Fig. 1. Sensing device for control of height of cane being fed to mills.

In Fig. 2, we show two typical charts: one is of No. 3 Mill working automatically, the other one is of Mill No. 4, working manually.

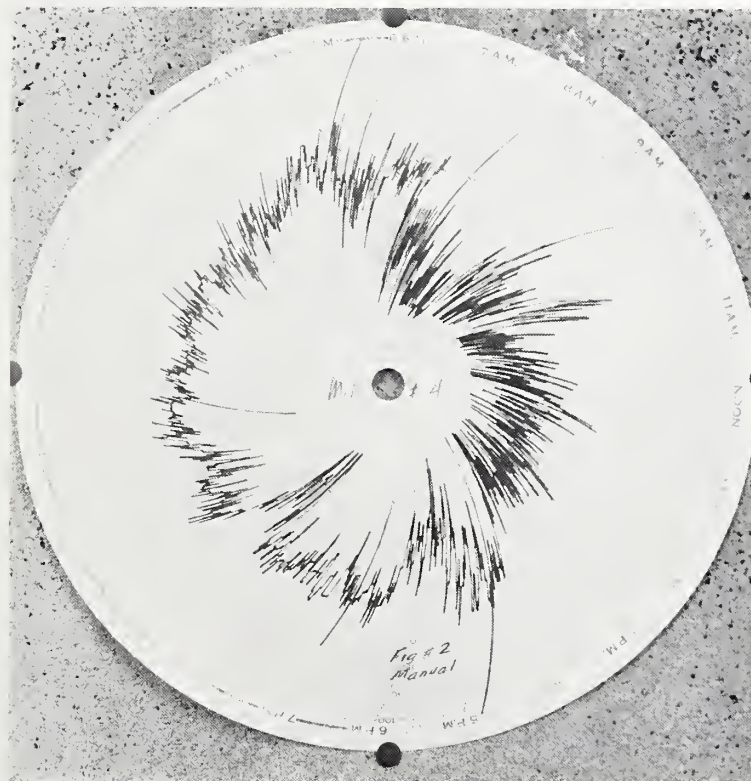
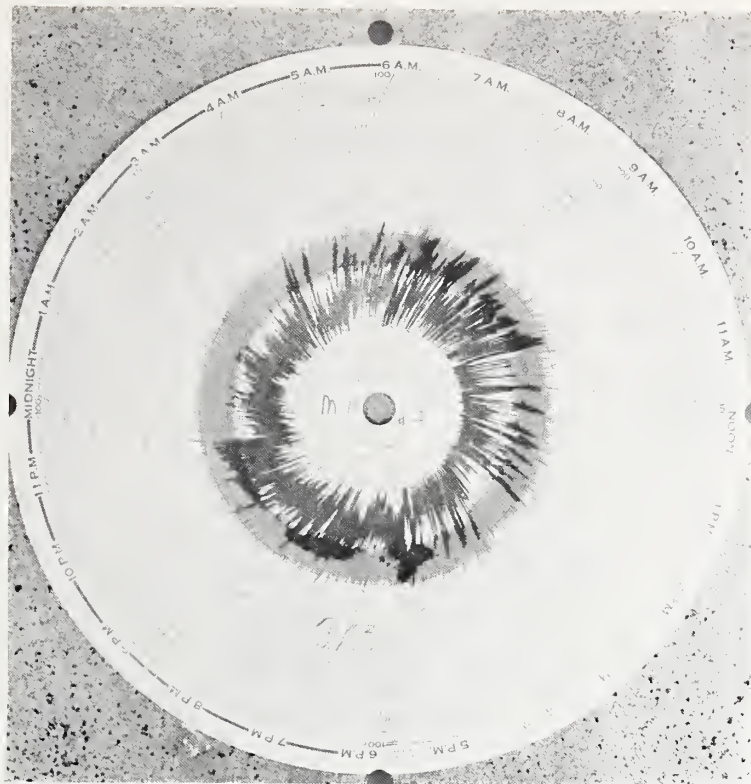


Fig. 2. Typical charts of cane volume handled by mills with and without automatic control. Upper chart: Mill No. 3 with automatic control. Lower chart: Mill No. 4 with manual control.

Fig. 3 shows Mill No. 7 under automatic control and Mill No. 7 under manual control.

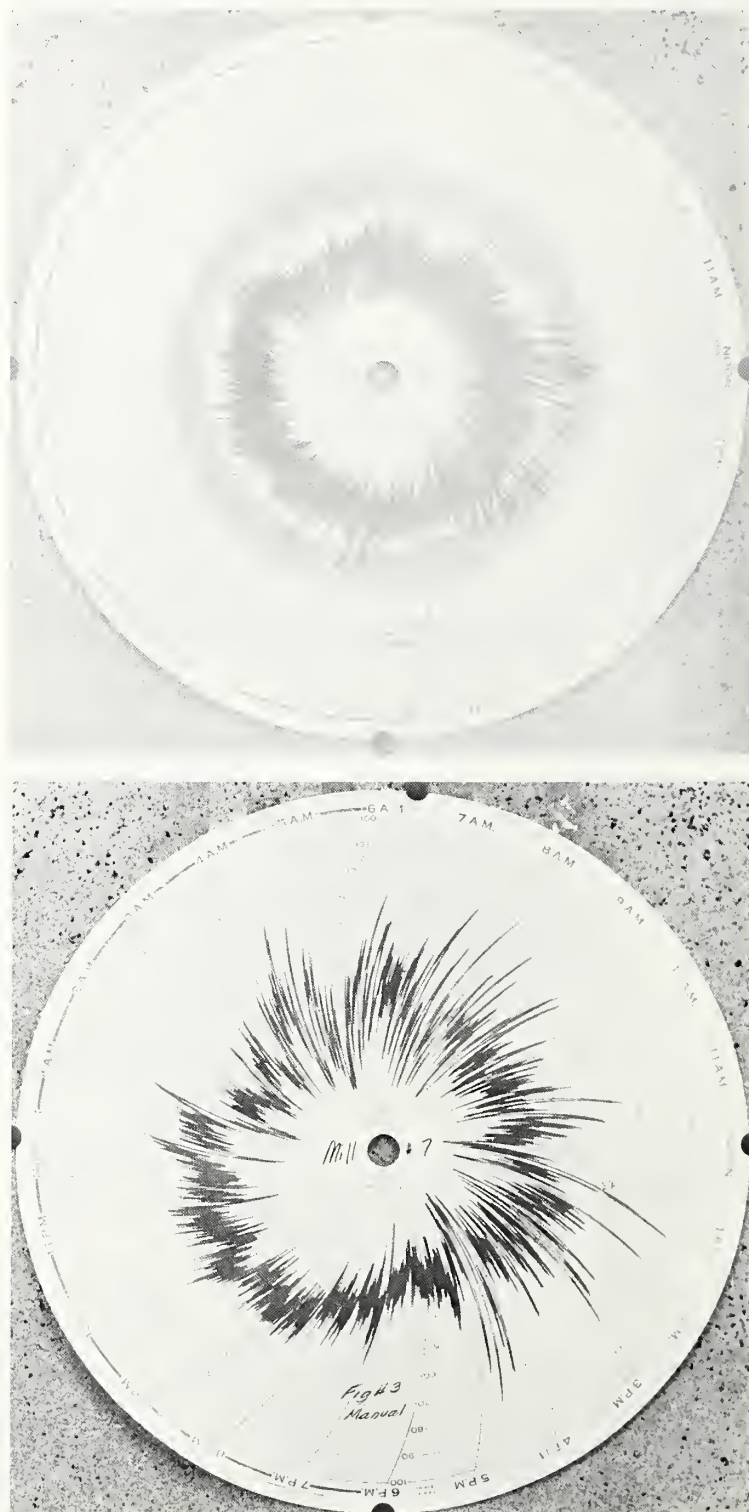


Fig. 3. Typical charts of cane volume handled by mills with and without automatic control. Upper chart: Mill No. 7 with automatic control. Lower chart: Mill No. 7 with manual control.

The range of the charts is such that 100% of the chart represents 1 inch of lift of the top roll.

In the above charts, we can observe a much more even lifting in those mills operating under automatic control.

The mill tandem at Glades Sugar House has established several records of grinding capacity with a very fair extraction, and we credit automation with a great percentage of our successful operation.

Automation eases to a large extent, the work of the mill foremen, and provides us with the advantage of grinding at different top roll lifts to determine which one is the best to combine capacity and extraction, that is, to attain efficiency.

Another useful automation feature we have in our grinding plant, is that shown schematically in Fig. 4, which consists of one complete motion interlocking from the last bagasse conveyor to the first auxiliary cane carrier.

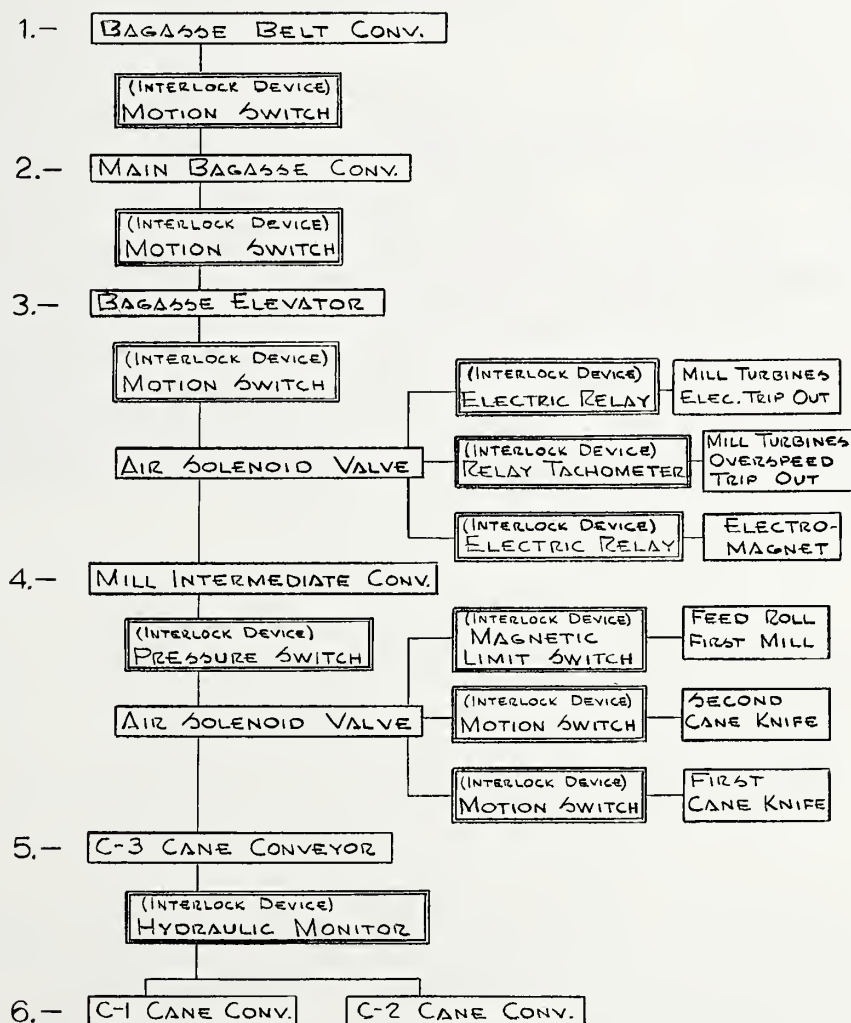


Fig. 4. Schematic representation of system for interlocking control of movement of cane and bagasse.

If something should happen in any of the moving units down the line, the system would automatically stop the rest of the equipment in reverse order. In this manner, the plant attendant knows at once which unit caused the trouble.

Fig. 5 shows the graphic panel depicting the interlocks with indicating lights. The only thing the plant attendant has to do when something happens is to look at the panel board to find out which equipment caused the problem.

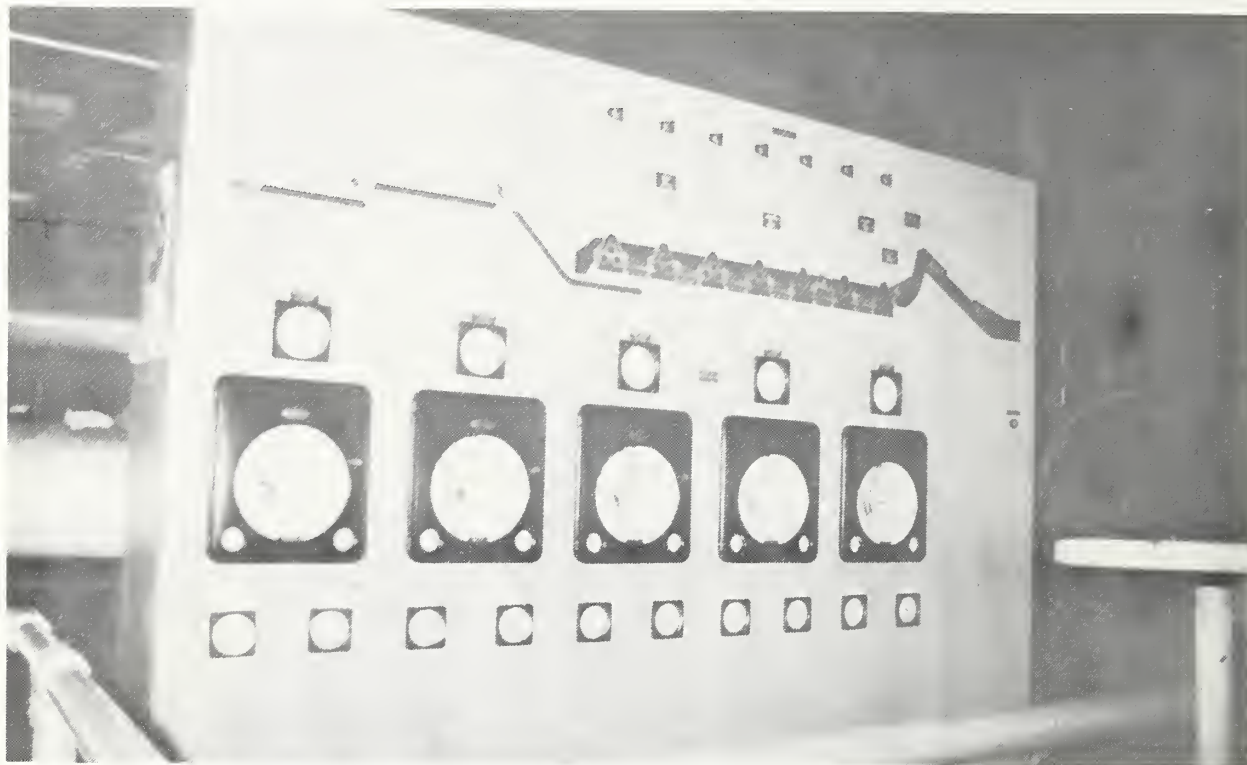


Fig. 5. Photograph of panel depicting interlocking control devices.

EVAPORATING PLANT

It is at this stage of the sugar fabrication process where automation results are most beneficial. All of us know very well that the evaporating plant is the heart of the sugar factory, and that the latter will be only as good as its evaporating plant.

Automation of the operation of the multiple-effect evaporator has been known for a long time, but for one reason or another has not been widely used. Many difficulties have been found on the way and, little by little, have been conquered; and today there is no excuse for operating multiple-effect evaporators manually, depriving yourself and your plant as a whole of the advantage provided by this automation.

Density Control.

We have found that the best way to operate a multiple-effect evaporating plant automatically is that based on the density of the syrup being drawn from the last vessel. The density control instrument will allow more or less syrup to be pumped out, causing a variation in the syrup level within the vessel that will instantly be adjusted by the level control valve in the pipe from the preceding vessel.

Thus, the control will go backward up the line to the first vessel, where the feeding control valve will admit more or less juice to keep the proper level in this vessel. The action of this valve will be reflected on the level of juice in the evaporator supply tank. The level in this tank will act upon the steam valve of the evaporator, admitting more or less steam. This last control could be called, cascade control, or two-step control. That is, you pre-set the average amount of steam normally required by your evaporator to maintain the level in the supply tank, about half of the height; then, as this level goes higher or lower, it will reset your pre-set amount of steam to the evaporator.

Fig. 1-E shows the density control we have found to be most suitable.

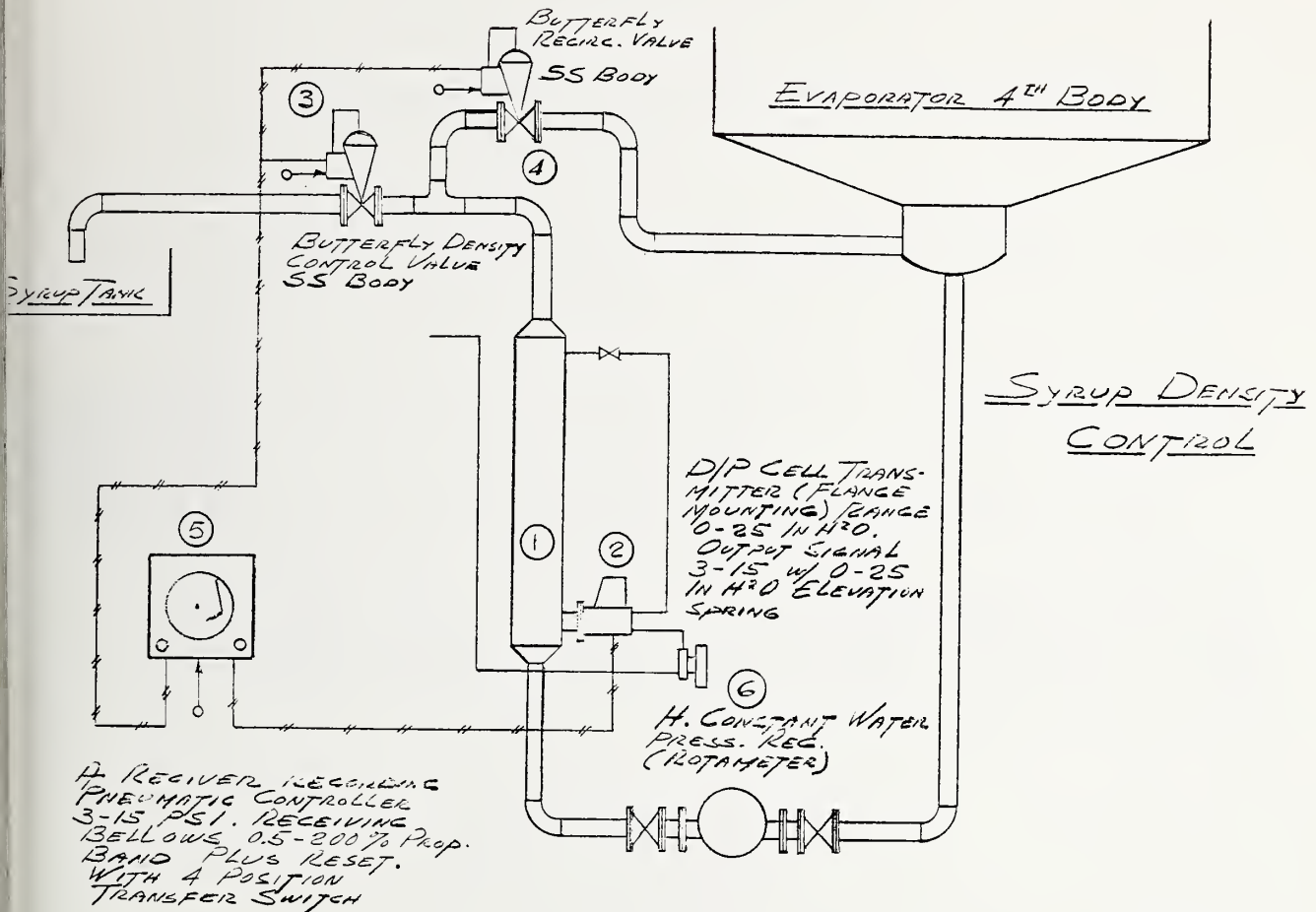


Fig. 1-E. Elements of the syrup density control.

The elements of the syrup density control mechanism in Fig. 1-E are:

1. Measuring chamber: This is just an enlargement of the section of the discharge line of the pump to bring down the velocity of the syrup being pumped low enough so as to avoid dynamic interference with the measurement.

2. D/P cell transmitter.

3. Butterfly control valve.

4. Butterfly recirculation control valve.

5. Receiver recording pneumatic controller.

6. Constant water pressure regulator (rotameter) to maintain the reference water column.

Level Control. Fig. 2-E shows the elements of the level control, which are:

1. Pneumatic D/P cell transmitter.
2. Butterfly control valve.
3. Pneumatic indicating receiver controller.

EVAPORATORS LEVEL CONTROL

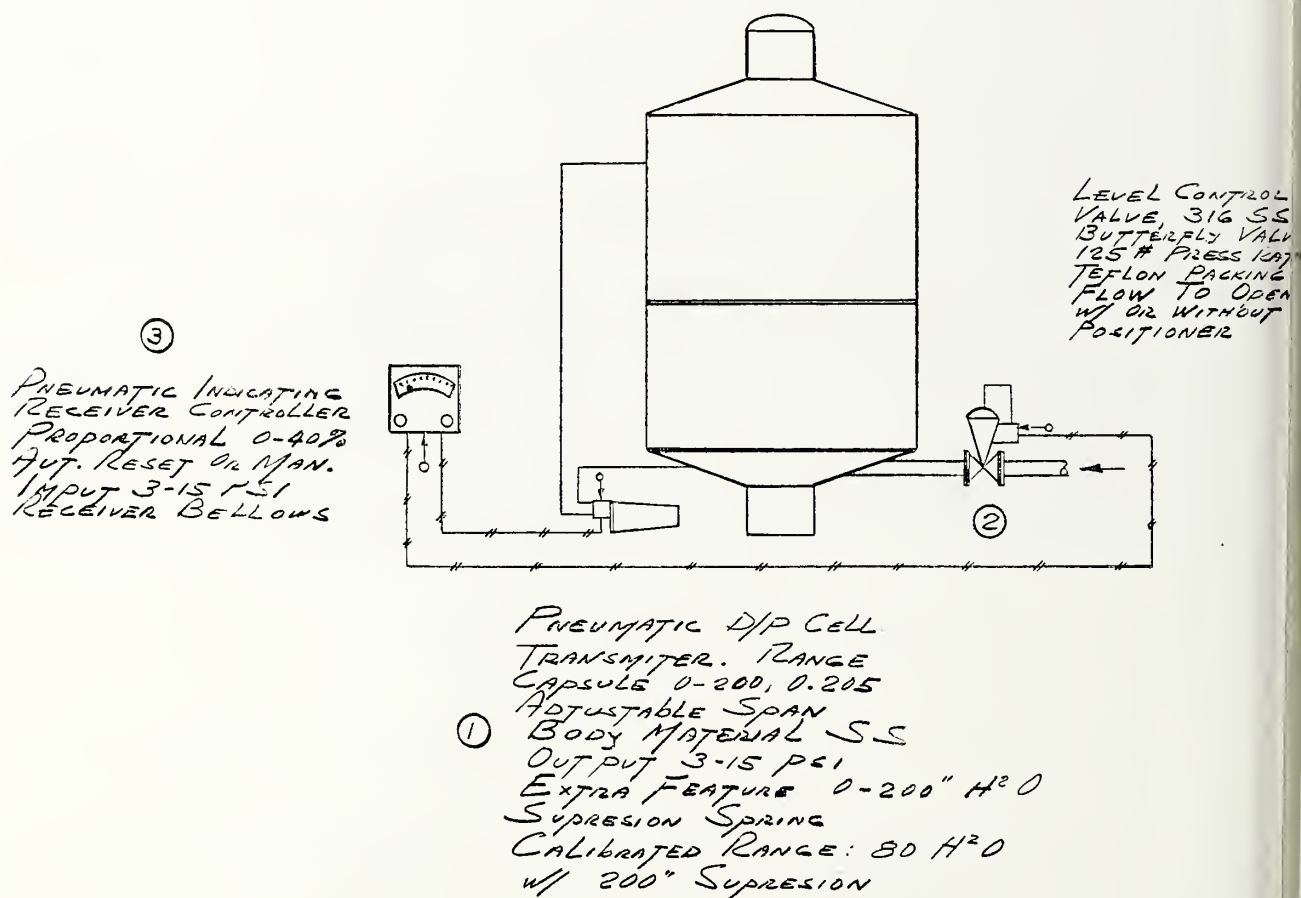


Fig. 2-E. Elements of the syrup level control.

Vacuum Pan Automation. The automation of the vacuum pan starts with the control of the vacuum (or temperature) under which the massecuite is being boiled; but we will not elaborate on this control, because it is quite simple and well known and we do not think it necessary to consume time explaining it.

So, we will go on to the automatic control of the feeding of syrup and/or molasses.

We have found that the best control so far, is that which does the same thing that we have been doing with our fingers ever since the very beginning of the sugar industry, but accomplished today with the aid of mechanical devices that do the work constantly and independently of the human senses.

In getting an element rotating within the boiling massecuite, and measuring the power required to make it rotate, we are doing the same thing that we formerly did with our fingers, but this time, in a constant and uniform manner. Then, this power is transformed into electric and pneumatic signals that operate the pan feeding valve.

The elements of the above control are:

a) Case of vacuum pan not equipped with mechanical circulators:

1. Sensing device: Consistency probe and transmitter.
2. Electric pneumatic transducer.
3. Receiver recording pneumatic controller.
4. Control valve: butterfly type.

With the above described elements, we set the set-point of the controller (item 3) in the position that corresponds with the consistency under which we wish every massecuite to be boiled (determined experimentally), and then let the control take over the feeding of the pan. As the pan goes up, we can, if necessary, raise the set-point to points of higher consistency until the strike reaches the point of being boiled down.

At this moment, we shut off the block valve in the feeding valve manually and watch the indicator needle of the recorder until it reaches the point corresponding with the consistency (brix) at which we desire to discharge the massecuite from the pan. Then we manually close the steam valve to the pan and the water valve to the condenser, and discharge the pan.

Of course, all the manual operations we have described above can be performed automatically very easily by means of D/P cells, etc., but since they do not have the importance that the proper feeding does to the efficiency of the massecuite boiling, we will not go into these aspects in this paper.

b) Case of vacuum pans equipped with mechanical circulators:

In this case, the automatic control of the feeding is easier, we might say.

Then the consistency probe will be the circulator itself and the transmitter will be its electric motor. The rest of the elements will be as in the preceding case.

THE APPARENT PURITY AND THE EXHAUSTION OF FINAL MOLASSES

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ABSTRACT

One of the biggest losses of sugar in our industry is that which goes to the final molasses. Many operating factors affect the exhaustibility of the residual molasses, but viscosity is considered one of the most important since it limits the concentration of the massecuite and the supersaturation of the molasses. The direct polarization of a final molasses sample is greatly influenced by reducing sugars and reducing substances, and the composition of the nonsucrose sugars of molasses has a very important relation to the degree to which it can be exhausted. Through the years in the sugar industry it has been considered that final molasses with an apparent purity close to 30 is a good indication of a final molasses being well exhausted of its sucrose content. For better illustration we prepared a table by taking 16 final molasses analyses out of the 1972-73 crop, from different places, and arranged them according to the apparent purity, and using the ratio of total sugars on brix calculated on 100 brix.

INTRODUCTION

The main interest in a sugar factory is to crystallize the maximum possible amount of the sucrose contained in the juice and to produce the minimum amount of final molasses with a minimum of crystallizable sugar in it.

Through the years in the sugar industry it has been considered that final molasses with an apparent purity close to 30 is a good indication of a final molasses being well exhausted of its sucrose content, but beginning about 20 years ago this method of judging was no longer used by many sugar factories around the world, which estimate their performance by considering the total sugars and not the apparent purity of the residual molasses.

Many operating factors affect the exhaustibility of the final molasses. Prinsen Geerligs showed in his classic thesis that the reducing sugar content and the ash content both influenced the amount of sugar that could be extracted from the molasses. Viscosity is considered of great importance since it is one of the factors that limits the concentration of the massecuite and the supersaturation of the molasses.

The composition of the nonsucrose sugars of molasses has greatly influenced the degree to which it can be exhausted, and many tests and studies of the residual molasses have been conducted by sugar technicians between the relationship of nonsucrose sugars to exhaustibility.

CONSIDERATIONS

The method of judging the exhaustibility of the final molasses by the apparent purity is useful only when the molasses contains a constant amount of ash and invert sugar, which makes it more or less comparable. However, with the progress of the crop and maturity of the cane, the relation of sucrose to reducing sugars changes and the direct polarization will change, resulting in a different apparent purity.

The brix determination by double dilution, using the brix hydrometer, is generally employed in all sugar factories. This determination of brix in the final molasses is usually made without permitting all suspended and insoluble solids to settle down since they affect the apparent purity.

The direct polarization of a final molasses may increase or decrease according to the amount and composition of reducing sugars and reducing substances. In some molasses there is a great variation of dextrose and levulose content, which may influence the direct polarization erroneously, resulting in a high apparent purity when the dextrose content is predominant.

In many instances sugar factories have considerable inversion throughout the manufacturing of raw sugar, yet in spite of that they show low losses of sucrose in final molasses.

RESULTS

It is known that several empirical formulas have been developed for the calculation of the expected maximum exhaustibility of the residual molasses, but the one we are using was recommended by V. E. Baikow (Sugar Journal, Dec 1951), who proposed a ratio of total sugars on brix and calculated on 100 brix, based

only on the sucrose by clerget, reducing sugars and hydrometer brix determined in 1:1 dilution of molasses, after 2 hours settling.

After testing several thousands of blackstrap molasses samples from different parts of the world over a period of years Baikow considers that for practical purposes a final molasses which contains 52% total sugars at 88 brix is well exhausted. According to these basic figures he found a ratio of 59, which represents target total sugar content in exhausted final molasses.

For better illustration we prepared a table by taking 16 final molasses analyses out of the 1972-73 crop, from different places, and arranged them according to the apparent purity. Looking at the comparison table we noticed that better total sugar extraction corresponds to the molasses that has a high apparent purity, with the exception of the no. 2 molasses analysis.

Judging the exhaustion of the molasses by the apparent purity, the no. 2 analysis appears to be better exhausted than the no. 12, but actually the total sugar brix ratio of both these molasses analyses is almost the same.

The analysis of molasses no. 6 and no. 7 has exactly the same reducing sugar content and almost the same apparent purity. Nevertheless, from the total sugar: brix ratio, it can be seen that from molasses no. 6 an additional 2.59% of sucrose could be extracted.

If we take the no. 11 analysis of molasses, which has an apparent purity of 39.31, we notice that the total sugar: brix ratio of this molasses is 58.37, and no. 9, which has a lower apparent purity (39.11) and has even less sucrose content, shows a total sugar: brix ratio of 61.34. It is probable that in the raw sugar factory that produced the no. 9 molasses analysis, inversion occurred or the cane was rich in reducing sugars. These 2 samples can be compared to sample no. 10, which has a much better exhaustion of molasses factor.

The no. 15 and no. 16 analyses have extremely high apparent purities. The no. 15 molasses is well exhausted, while the no. 16 contains an excessive amount of sugars.

Molasses no. 1 has a lower apparent purity than no. 5. The total sugar: brix ratio of no. 1 is 58.58, while no. 5 shows 57.96.

CONCLUSIONS

Two important facts have been disclosed from the analyses of the final molasses in the comparison table: 1) The apparent purity is meaningless in cane molasses, and 2) There is a limit to which sucrose can be extracted from the residual molasses.

It appears that a certain amount of sugars is retained in the final molasses which could be a combination of sucrose and reducing sugars or sucrose alone.

If the percentage of reducing sugars is low, more sucrose is retained in the final molasses. This occurs quite often when sugar cane is mature. On the contrary, when inversion occurs throughout the factory, it is difficult to crystallize additional sucrose because an excessive amount of reducing sugars prevents further crystallization.

According to this, a ratio of total sugars % brix ought to be indicated as a target for a well exhausted molasses in the sugarcane industries of Louisiana and Florida. Mathur recommends that for conditions in India the ratio of total sugars % brix should not exceed 55.5%. Baikow previously proposed a ratio of 59. We suggest that a total sugar % brix ratio of 55 should be our target.

COMPARISON TABLE

<u>No.</u>	<u>Degree Brix</u>	<u>Direct Pol.</u>	<u>App. Purity</u>	<u>Sucrose Clerget %</u>	<u>Reducing Sugars %</u>	<u>Total Sugars %</u>	<u>Ratio Total Sugars Per 100 Brix</u>
1.	88.65	30.65	34.57	37.96	13.97	51.93	58.58
2.	86.96	30.31	34.86	35.49	12.72	48.21	55.44
3.	90.66	31.65	34.91	36.55	15.35	51.90	57.25
4.	91.74	33.44	36.45	39.00	15.70	54.70	59.63
5.	88.52	32.47	36.68	37.14	14.17	51.31	57.96
6.	87.91	32.89	37.41	39.00	12.32	51.32	58.38
7.	86.45	32.75	37.88	35.91	12.32	48.23	55.79
8.	88.73	34.69	39.10	38.71	11.33	50.04	56.40
9.	87.45	34.20	39.11	39.23	14.41	53.64	61.34
10.	92.18	36.19	39.26	39.78	11.00	50.78	55.09
11.	88.25	34.69	39.31	40.35	11.16	51.51	58.37
12.	91.50	36.36	39.74	40.70	9.83	50.53	55.22
13.	89.31	36.21	40.54	40.90	9.76	50.66	56.72
14.	93.63	38.11	40.70	41.47	10.90	52.37	55.93
15.	92.86	38.16	41.09	42.30	9.46	51.76	55.74
16.	88.72	36.57	41.22	39.68	17.24	56.92	64.16

PARTICULATE SAMPLING IN A LOUISIANA CANE MILL

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This paper describes sample collection and subsequent analysis of particulate emissions from a Louisiana sugar cane grinding mill. The information obtained from this testing program was necessary to complete an emission inventory questionnaire form required by the Louisiana State Air Control Commission.

Parameters required by the Commission are: The emission concentration in parts per million (ppm), the rate of emission in cubic ft per second (cfs), the emission temperature, and the exit velocity. In addition, the particle size distribution of the carbonaceous particulates and the mineral solids particulates were required.

The Louisiana State Air Control Commission specified 2 acceptable test methods for particulate emission testing at new sources: the American Society of Mechanical Engineers Power Test Code 27 and the Environmental Protection Agency (EPA) Test Method. The testing described in this paper follows the EPA Test Method; however, both methods are basically alike.

Several manufacturers have equipment available to conduct stack sampling for particulates. The entire sampling train can be thought of in 3 sections: The probe, the sample box, and the control module. The probe and part of the sample box are heated to keep moisture from condensing, which would cause the particulates to adhere to the sides, eventually clogging the system. Particulates can be removed in an optional cyclone, and most of the remaining particulates are removed using a fine fiberglass filter. The gases flow through the heated filter into a series of impingers and bubblers suspended in an ice bath. This causes the moisture in the stack gas to condense and remain in the cooled section. The final tube is filled with a drying agent to entrap the remaining moisture. The control module houses a vacuum pump and a meter to draw the sample through the system. Thermometers measure temperature in the stack and at several positions in the system.

To obtain a truly representative sample of the particulates flowing in the stack gas, an iso-kinetic sample must be taken. This means that the velocity at which the particulate is drawn into the sampling probe must be the velocity at which the particulates are moving at that location in the stack. An iso-kinetic sample is necessary because the particulates are heavier than stack gas. If the velocity of the sample entering the probe is lower than the velocity in the stack, the stack gas will tend to be deflected around the probe; but the heavier particulates will tend to flow straight into the probe. This situation would yield test results indicating a heavier concentration of particulates than was actually present. If the sampling velocity was greater than the stack gas velocity, a larger volume of stack gas would be drawn into the probe than would be proportionate to the concentration of particulates. This situation would yield test results indicating a lower concentration of particulates than was actually present. The velocity of the gas in the stack and the velocity and total volume of the sample being drawn in are also measured. By measuring the weight of the particulates collected and the volume of the moisture condensed, the particulate and moisture concentration of the stack gas can be determined.

The location of the sampling ports and the position of the probe in the stack are critical factors. If locations along a stack or duct are available where the gas is flowing in a smooth even flow, the number of positions in the stack from which a sample is drawn can be reduced. Twelve positions are a minimum, based upon the distance upstream and downstream to a bend, expansion, or other disturbance. A minimum of 5 minutes of sampling at each position is required by the EPA. It is easy to see that proper location of the sampling ports can make the difference between a 1 or 2 hr sampling time as opposed to an all day job.

Now that the method of sampling and some considerations pertaining to this testing have been briefly discussed, let us now look at the value of this type of testing. A comparison of the concentration of the emission from several stacks at a mill can indicate on which stack emphasis should be placed, if the total mill emission does not comply with regulations. Also, by examining values for emission rate, temperature, and exit velocity, operational procedures can be investigated in an effort to reduce total mill emissions by balancing the bagasse loading to the boilers to improve combustion, or perhaps by reducing the velocity at which the particulate-laden stack gases pass through a fly ash arrester. Consideration of the complete results of the testing and comparison between each stack at a mill will be unique and require individual study; however, the point I would like to make is, that a thorough testing program can point out problem areas within a mill, and the data acquired may suggest economical methods of reducing particulate emissions. In addition to the above information that can be derived directly from the EPA test procedure, determination of the particulate sizes and ash content of the various sizes can be enlightening.

The tests I conducted at one Louisiana sugar mill were carried out on 2 similar stacks which we called Stack A and Stack B. The same procedures were used for both stacks. A fly-ash arrester was in place on Stack B, and there was no arrester on Stack A. The particulates were separated using sieve methods down to the 43 micron size. Air elutriation was used to further segregate the finer particulates. Our findings were that 10% of the particulates emitted from Stack B were larger than 150 microns; whereas, 48% of the particulates emitted from Stack A were larger than 150 microns. These figures indicate that the fly-ash arrester on Stack B was effective for particles larger than 150 microns. The data also give an indication of the amount of improvement that could be expected if a similar fly-ash arrester was installed on Stack A.

After the particulates were separated into size classifications, the percentage of carbonaceous material in each size group was determined by ashing portions of each sample. These tests showed that approximately 97% of the particulates smaller than 150 microns consisted of mineral solids. Mineral solids are defined as those which are not consumed after being heated 45 minutes at 600 C. Principal sources of this type of material in bagasse are the small percentage of bagasse that remains after burning and unburnable material mixed with the bagasse, such as field soil. This testing program was conducted during extremely muddy field conditions with heavy accumulations of field soil in the bagasse fuel. These facts raise the question: How much of the total particulate emission was contributed by field soil accumulations? The answer to this question could be particularly significant when considering the fact that the fly-ash arrester was efficiently handling particulates larger than 150 microns.

Gentlemen, I hope the presentation has contributed to your understanding of a particulate emission testing program and the uses of the information that can be obtained.

REFERENCE

Federal Register. 1971. Vol. 36, No. 247 - Thursday, December 23.

ASPECTS WHICH AFFECT CLARIFICATION AND THE REMEDIES
GREENWOOD FACTORY USES TO COMBAT SUCH ASPECTS

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Greenwood Factory
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With our present day milling methods and procedures, more sucrose is extracted, but at the same time more impurities are also extracted. These impurities require special attention at the defecation and filtration stations. Since the fields are almost totally mechanized, we in the factory have felt in the past few years a tremendous impact of high trash and mud. Some do a fairly good job of washing, but as you know, many cannot use as much water as is required to do a real good job because we lack pond capacity or do not have enough fresh water.

Another thing that raw houses have to contend with is the quality of raw sugar. Today, refineries are looking not only for premium sugar, but clean sugar which is free from mud and bagacillo, along with low ash, filterability and invert. These items could really be out of line because of poor clarification. The quality of raw sugar produced depends highly on the defecation and filtration stations.

With all of this in mind, I will try to point out some control measures which were put into effect at our Greenwood Factory which really worked. Let me make one point definitely clear. What I am about to bring up worked at our mill. It might not work for some of the mills represented here today.

Better clarification depends on a lot of things prior to the liming itself. I will point out some precautionary measures which we follow at Greenwood and I feel are considered very important.

THE PREPARATION OF CANE

The cane coming to the mills today has a very high trash and mud content due principally to mechanization and occasionally adverse weather conditions. We should all try to wash out as much mud as possible before the cane gets to the knives. This will alleviate much mud and some trash which would hinder the clarification process. One thing we should all keep in mind is the fact that cane on the yard should not be kept for any extended period of time. Each mill has its own procedure, but ours at Greenwood is to get the cane off the yard in less than 48 hr, if possible. By doing this we cut down the acidity and sugar losses. These conditions will vary with the temperature and weather conditions.

Whole-stalk cane has a lower acidity rise than cane cut by the combine harvester, which cuts in small pieces. With small pieces of cane, the stacking time should be no more than 24 hr unless weather conditions interfere, and even with this some will show high acidity. This step should be considered carefully and precautions should be taken to avoid sugar losses and poor clarification.

MILLING PROCEDURES

One item which is very important in the milling procedure is the cleanliness of the mill. Too many times one can go around a mill and find *Leuconostoc* bacteria. Since the stalks delivered to the mills contain a high concentration of bacteria which would result in sugar losses, mill sanitation should be followed. Some of these micro-organisms are washed off prior to the knives, but most of it is washed off with the extracted juice. If the temperature is within their growth limits, then they will multiply immediately. To prevent this we have found the best and cheapest solution is the washing of the mills every 8 hr with hot water. To stop such microbial action, we at Greenwood wash our mill with hot water every 8 hr, and chlorine is added to our crush-crush. The amount of *Leuconostoc* bacteria found around our mill was nil.

If hot water is not available, you can wash with cold water; but you have to add an agent like Busan or chlorine. We have found that cane damaged by a freeze or old cane shows more and quicker microbial action on the juice extracted. This causes the purity to be reduced and a high quantity of gums in our pans. Because of this, one will find the clarification of juices extremely difficult and the yield of sugar to be reduced.

There are various methods which are used in purification of juices, such as:

- 1) Defecation - treatment with lime.
- 2) Sulphitation - treatment with sulphurous acid.
- 3) Phosphatation - treatment with phosphoric acid.
- 4) Carbonatation - treatment with carbonic acid.

The most universal in the raw sugar factories and the one we are familiar with at Greenwood is defecation.

At Greenwood we use hydrated lime. It is mixed in 2 tanks with stirrers to a 5° Baume milk of lime solution. By having 2 tanks, one can be filled while the other is being used. Some factories, we are told, still use lime in a solid state, which is not recommended because some portions of juice will be overlimed while other portions are insufficiently limed. The milk of lime on the other hand has a more uniform distribution of lime throughout the juice. If the milk of lime is mixed too heavy, it will stop up the pipes quite often and cause frequent trouble with the automatic pH controller. Many people use 2° to 3° Baume milk of lime, which is good, but more milk of lime is needed, meaning that batches have to be made more often.

The cold juice coming from the mill is limed to a pH of 7.1 - 8.3, whatever is required to get the defecated juice to the condition required for better settling and clarification. I will cover in detail the procedure used at Greenwood later in this paper.

Once the liming of cold juice extracted from the mills is complete, we go through heaters. We always try, and have been very successful, to keep our juice heated to 220 F. One should never go below 216 F, if at all possible, because proper temperature means good clarification. On leaving the heaters the juice passes into our flash tanks in order to release vapors to the atmosphere and bring our juice temperature down to the boiling point of 212 F.

The lime and heat process forms a heavy precipitate in the clarifiers.

The quantity of the precipitate of mud and scums depends on the variety of cane, the maturity, lime, heat and the freshness of the cane. The clarified juice drops to a pH of 6.4 - 6.8. If the juice is on the cold side, say 200 F, out of the heaters, you will find a problem of precipitation and also a good chance for inversion, which results in sugar losses.

I would like to point out that we have continuous polymers (such as Separan or Nalco) added to our clarifiers to help speed up the precipitation of mud and scums. We use approximately 5 lb of polymer diluted in 1000 gal of water every 6 hr.

Clarification affects the evaporators, pan boiling, centrifuging, the quality of the produce and most of all the yield of raw sugar. Poor filtration and quality of refined sugar can be traced right back to clarification. Too little lime will give poor settling and the juice will be cloudy, but most important is the possible sugar losses by inversion. Too much lime causes the juice to be dark, gums in low grade product appear, ash content increases and the molasses output is high. It also slows down the work of the pans and affects the crystallization process.

Our procedure at Greenwood is continuous liming. When the grinding season starts, the cane is not mature and the brix, sucrose and purity are low. We lime our cold juice to a pH of 7.1 to 7.5 so that we get a clear juice pH of 6.4 to 6.6. I like to hold it somewhere between 6.4 to 6.5 as much as possible. With a low brix, anywhere from 14 - 16, the settling of mud and scums is speeded up and little time is required for mud to be pumped out to the filters. This is why less lime is required. As the crop progresses along and the cane matures, the pH is increased to suit. We find that as the cane matures, which is about 2-4 weeks after grinding starts, the pH is increased anywhere from 7.5 to 8.0 so that we can get a clear juice with a pH of 6.6 to 6.8. Never go over 6.8 because you will run into the problem of overliming. This will upset your clarifiers, result in burnt juice and also a poor grade of sugar. It must be remembered that the increase of brix as the cane matures contributes to the decrease in speed of settling the mud and scums. This is why more lime is required.

In Louisiana during 1972, we experienced one of the worst weather conditions since mechanization of the fields. This brought about not only high trash and mud but also the grinding of some frozen cane and some high acidity cane.

Let us examine some statistics of our normal juice, brix, sucrose and purity along with acidity.

Table 1. Quality of normal juice on various harvest dates in 1972-73.

Date	Temperature	Normal Juice			
		Brix	Sucrose	Purity	Acidity
10-13-72	60	15.77	11.94	75.72	1.70
10-31-72	66	16.31	12.89	79.01	1.90
11-15-72	46	15.49	12.08	77.96	1.90
11-30-72	42	15.44	11.99	77.68	1.90
12-15-72	48	14.67	11.52	78.50	1.90
12-16-72	32	14.09	10.90	77.35	1.80
12-17-72	30	14.87	11.63	78.20	1.80
12-18-72	31	15.21	11.86	77.97	1.90
12-27-72	30	15.41	12.01	77.91	1.94
12-28-72	31	14.99	11.72	78.18	2.07
12-31-72	62	15.10	11.79	78.10	2.07
1-11-73	* 32	13.74	10.66	77.59	2.21
1-12-73	29	13.90	10.76	77.40	1.92
1-13-73	24	13.67	10.32	75.46	2.14
1-14-73	33	14.18	11.00	77.54	2.12
1-15-73	39	13.83	10.57	76.40	2.30
1-16-73	39	13.82	10.47	75.75	2.28
1-17-73	49	13.82	10.46	75.69	2.28

* Snow and sleet

Also you will note the temperatures for certain days. In comparing these, one can readily see when high acidity hit our factory.

Some people have the impression that if the acidity of cane is on the way up, the lime added to the juice should be increased to offset the acidity. This is wrong and should not be done. The way we approached such a problem was to check the brix, sucrose, and purity. Once we saw that these went down, especially the brix, because this will show a decrease immediately, then our lime was decreased to obtain a clarified juice pH of 6.4 to 6.6.

An example we had was that one of our shift superintendents had high acidity cane. In turn he added more lime. By doing this the settlers got all upset and no precipitation or very little took place -- 100% of the juice went to the filters. After seeing this, the first thing we did was to ditch some of the old mud, reduce the lime and start again. Almost immediately the clear juice was beautiful and our operations were successful again.

Before I conclude, I would like to point out one more important fact. Even though you have an automatic pH controller, it should have your constant attention. The pH of the limed juice should be checked periodically, at least every 4 hr against another machine. More frequent checking is desirable.

In conclusion, I would like to point out the major points to check for better clarification which worked real well for us at Greenwood and might be of some help to you.

- 1) Freshness of cane
- 2) Cane preparation
- 3) Mill sanitation
- 4) pH control on defecated juice
- 5) Heating of juice to 218 F - 220 F
- 6) Checking the pH controller periodically.

PNEUMATIC CONVEYING OF BULK BAGASSE IN LOUISIANA

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I was asked to convey to you our experience with new pneumatic bagasse-conveying systems installed last year. Well, the 1972 crop is behind us now and our experience can be summed up in one word, "Disappointing".

In the following text we will elaborate on the factors which lead to bulk bagasse, the reasons for our equipment selection, the details of our experience and our plans for the 1973 crop.

Because of corporate relationships originating in the establishment of The South Coast Corp., the bagasse production of our company has historically been dedicated to the Marrero plant of the Celotex Corporation.

Because of the continually mounting costs, the difficulty of obtaining manpower to seasonally operate a baling plant, and after studying the successful storage of bulk bagasse in other countries, South Coast in conjunction with Celotex decided to store bagasse in bulk at our smallest sugar mill for the 1970 crop. At this installation we were able to select a storage site fairly close to the mill discharge conveyor and installed an overhead belt conveyor, approximately 400 ft long, to convey the bagasse to a radial stacker. The stacker is an incline belt conveyor, approximately 165 ft in radius, pivoted at lower end and discharging at a 60 ft elevation above ground. The stacker is mounted on rubber tire wheels and travels at 300° arc, to form a horseshoe-shaped storage pile. The cost of the overhead belt conveyor at this initial installation was approximately \$80.00 per ft.

The bagasse stack is constructed in horizontal layers through continuous traversing of the incline stacker, as opposed to vertical stacking.

To date, we have found that optimum preservation of fiber is achieved by maintaining a high moisture content through the fermentation process; hence, water is sprayed on top of the pile during and for several months subsequent to the completion of the grinding season. A mobile vehicle is not used to secure compaction essential to anaerobic condition; excess water accomplishes same. Storage by this method has resulted in excellent quality bagasse for Celotex's use.

Therefore, in 1972 South Coast decided to expand the bulk bagasse-storage facilities to 2 of its other sugar mills, namely; the Raceland mill with a 5500 ton/day capacity and Terrebonne mill with a 3000 ton/day capacity. However, at these 2 plants the only available storage sites were approximately 1500 ft from the mill conveyor. We again planned to use the inclined stacker concept, similar to the original installation, to create horseshoe storage piles. To convey the bagasse from the mill to the stacker required an overhead conveyor approximately 1500 ft long at each location. The storage of bulk bagasse at the Raceland plant was further complicated by the following conditions.

1. Because of the larger grinding capacity, it was necessary to use 2 radial stackers to store one crop.
2. Because of the shipping schedule to satisfy Celotex's inventory requirements, it was necessary to provide adequate storage sites for 2 crops.

These parameters necessitated maximum flexibility in bagasse conveying. In addition to belt conveyor bids, we decided to get a bid on pneumatic conveying from the Rader Corp. of Portland, Oregon. The results were that the price of a pneumatic installation was approximately one-half that of a belt installation.

We were aware that bagasse was being conveyed successfully pneumatically in Hawaii, Iran, and in South America, and that there were many wood chip and bark pneumatic installations in the USA. Thus, after looking at the relative costs, the flexibility, and the other successful installations, we decided to stick our necks out a little and purchase the pneumatic conveying systems for both sugar mills. We might add that the higher operating cost of the pneumatic system was considered also. The pneumatic system requires approximately 400 hp for a 5000 ton mill whereas the belt conveyors would have required approximately only 50 hp.

As a point of information, we wish to mention that the Rader Corp. of Portland, Oregon has installed most of the bagasse and wood chip pneumatic conveying systems around the world. According to our past records, the density of our bagasse varied from 6 to 8 lb per cu ft; therefore, the systems were designed to handle the full production from our mills at the maximum density of 8 lb per cu ft.

The main components of a pneumatic conveying system are a large positive displacement blower driven by a turbine, a large rotary air valve or feeder which injects the bagasse into the air stream, the conveying pipe line, (18 in. at Raceland and 12 in. at Terrebonne) and a cyclone at the end of the pipe line to separate the bagasse from the air stream.

As everyone in the Louisiana sugar industry will well remember, this past sugarcane grinding season was probably the wettest in the history books. The continuous rain and subsequent muddy field conditions resulted in abnormal amounts of soil entering the sugar mill with the cane. Most of you are aware of the normal headaches encountered in a sugar mill with excess rain and mud. We discovered that pneumatic conveying is also adversely sensitive to excess mud. We were able to complete the crop with these systems, but under difficult and costly circumstances.

On any new installation start-up problems or bugs are to be expected. These are normally eliminated in short time by various adjustments and modifications, but in our case the bugs never left us. The most common problems were a few line chokes, many elbow chokes, scrap iron in feeder, cyclone chokes, hi-pressure shutdowns, and turbine trips. The hi-pressure stops were due to a pressure switch, which upon sensing abnormal back pressure would shut down the bagasse in-feed to avoid a choke. However, on many occasions the switch action was not responsive enough to prevent a choke.

One serious mistake which created some of the aforementioned problems was the use of a turbine with a mechanical governor to drive the blower. When Rader advised us of the horsepower requirements, it was our suggestion to use turbines in lieu of electric motors because they were available at our plant. Rader approved their use, admitting, however, to having had little experience with same. Through an oversight we were not aware that the blower must maintain a constant speed from no-load to full load conditions. As most of you realize, the characteristics of a mechanical governor are such that it must lose approximately 15% of its rpm to open the steam valve for maximum load. The discharge pressure on the blower increases proportionately to the amount of bagasse injected into the air stream, consequently requiring proportionately more horsepower from the turbine. The mechanical governor could only deliver more horsepower by reducing its output speed, and resulting in proportionately less cfm from the blower. The result was havoc in attempting to operate under these conditions. We attempted to remedy this situation somewhat by increasing the no-load speed of the turbine and blower to off-set the loss in speed and cfm air capacity under loaded conditions. However, due to the maximum rpm rating of the turbine and the blower stipulated by the respective manufacturers, we were unable to get sufficient no-load speed to overcome the afore-mentioned rpm loss. The only alternative remaining was to operate at reduced capacity for most of the crop.

Another factor which contributed considerably to the aforementioned problem was high density bagasse. After numerous checks it was discovered that the density of our bagasse varied from 8 to a maximum of 10 1/2 lb per cu ft. It was obvious that the high density was due to the excess mud or field soil in the bagasse, which was the result of the abnormal rainfall. We did not have efficient cane washing facilities at most of our raw sugar factories. The Rader Corp. also concluded that Louisiana bagasse seemed to have a higher friction factor than that encountered at other bagasse installations in other sections of the world. These two factors, high density and friction, required considerably more horsepower than had been originally designed in the system. Consequently, the only alternative again left available to us was to grind sugarcane at a reduced rate.

It was through the perseverance of all of our operating and maintenance personnel that we were able to complete the grinding season. These Rader systems contributed about 4% down time based on total time. This does not include the loss due to reduced capacity.

After completion of grinding operations, we had a Rader representative inspect the system. His report revealed abnormal wear in the bagasse feeders and pipeline elbows only, which apparently was due to excess soil. All other equipment seemed to be in good shape.

After reviewing with Rader all of the difficulties encountered during the 1972 grinding season, we decided to try the pneumatic system again for the 1973 crop. Of course, this decision was based upon making some design changes recommended by Rader to overcome the aforementioned problems, namely, insufficient horsepower, constant speed turbine driver, and more air. We felt that our investment in the pneumatic system justified this action.

Therefore, prior to the 1973 grinding season, we will install a new turbine with a constant speed governor and a larger air blower on both systems. Another factor which should aid considerably in the operation of a pneumatic system for the 1973 crop will be cleaner bagasse. We plan to improve our cane washing facilities to remove excess mud from same.

In conclusion, we trust that our objective of enlightenment regarding pneumatic bagasse conveying has been accomplished. At this stage we can neither recommend nor reject the system. We will repeat that for long distance conveying there is a considerable saving in capital expenditure. After the 1973 crop it is hoped that we will be in a better position to give a recommendation.

EFFECTS OF INTER-ROW SPACING ON SUGARCANE YIELDS IN LOUISIANA

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ABSTRACT

Higher plant populations are essential for higher yields of sugarcane per hectare in Louisiana. Rows 0.9 and 1.1 m wide resulted in the highest populations and yields. Rows with 2 drills (38.1 cm apart) on rows 1.8 m wide yielded significantly more than standard rows when planting technique was improved. They were easier to manage than narrow rows. Rows with a wide drill (opened 38.1 cm wide) did not increase yields. Higher planting rates are not practical. Dual drills 0.5 to 0.9 m apart on rows 2.1 to 2.7 m in width will be studied in an attempt to make machine operations easier and obtain higher yields.

Editor's note: Only the Abstract of this paper was available for publication in the Proceedings.

MAINTAINING MAXIMUM YIELDS IN FLORIDA WITH SKIP PLANTING

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ABSTRACT

Increasing competition for new acreage to take advantage of allowable expansion of sugarcane production has occurred in the Florida muck lands in recent years. The possibilities of increasing production on present available acreage is explored and a program for increasing plant population as practiced by Beardsley Farms is discussed. The program consists of planting new seed pieces in skips or gaps within the established row or line. An explanation of seed cane varieties, opening of the furrow, planting, soil treatment and care of the plant growth is presented. Comparison of yields and subsequent longevity of ratoons is illustrated. Increases in tonnage of over 50% and in life of over 10 years have resulted from this practice.

Editor's note: Only the Abstract of this paper was available for the Proceedings.

YIELD AND NUTRIENT ELEMENT CONTENT OF ROOTS
AND BELOW-GROUND STUBBLE AS RELATED TO FERTILIZATION
OF SUGARCANE AND SOIL VARIATION

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ABSTRACT

Root and below-ground stubble yields were obtained from a field fertilizer experiment with plant cane and were analyzed for contents of macronutrient elements. The soil varied from Loring silt loam (Soil I) on the upper portion of the experimental area (slope = approximately 3%) to Loring-Olivier silt loam (Soil II) to Olivier silt loam (Soil III) on the lower portion of the area. Differences in cane yield due to soil variation were relatively large. No significant differences among root yields per acre were found but differences in root yields per ton of millable cane due to soil variation were statistically significant and were of the order: Soil I highest, Soil II intermediate, Soil III lowest. Root weight per ton of millable cane from Soil III was 30% lower than from Soil I, but cane yield from Soil III was 44% higher than from Soil I. There was a positive association between cane yield and below-ground stubble yield per acre ($r = 0.652$). However, since root production was much greater than stubble production, a highly significant negative correlation was found between cane yield and root and stubble yield ($r = 0.693$). Differences in contents of nutrient elements of roots and stubble from the fertilizer treatments were not statistically significant. Differences in nutrient element contents of roots and stubble per ton of millable cane due to soil variation were generally statistically significant and were of the order: Soil I highest, Soil II intermediate, Soil III lowest.

INTRODUCTION

At two locations in Louisiana in 1962, the average dry matter production of roots and below-ground stubble from plant cane was 128 lb per ton of millable cane (3). Results from similar work reported by Stubbs (6) in 1900 and obtained in experiments at Audubon Experiment Station, showed that the average root and below-ground stubble production by varieties of Saccharum officinarum was 124 lb per ton of millable cane.

Borden (1) conducted an investigation in Hawaii to determine the concentration of nutrient elements in roots and below-ground stubble of sugarcane. At the stage of growth comparable to the age of cane in Louisiana at harvest, Borden found that the N, P (expressed as P_2O_5), and K (expressed as K_2O) concentrations, dry weight basis, in roots and below-ground stubble were 0.65, 0.29 and 0.55% respectively.

Humbert (4) found in Mexico that the K (expressed as K_2O) contents of roots from cane grown in potassium-deficient soil and in potassium-sufficient soil were 0.36 and 0.60% respectively, and that the K (as K_2O) contents of below-ground stubble were 0.36 and 0.72% respectively.

Patrick et al (5), in a recent study conducted with 6 soil series throughout the sugarcane producing area of Louisiana, found that root content in the 6-24 in. depth showed a 3-fold increase associated with a 3-fold increase in average oxygen content. They reported that root concentration in the 6-24 in. depth was much higher in lighter textured Commerce and Cypremort soils than in the adjacent heavier textured Sharkey and Iberia soils, with Mhoon and Baldwin soils being intermediate.

The purpose of this study was to determine the relationship of yield and nutrient element contents of the below-ground parts of sugarcane to fertilizer treatment and soil variation.

MATERIALS AND METHODS

Root and below-ground stubble samples were obtained from a fertilizer experiment conducted in the field at Perkins Road Agronomy Research Farm in East Baton Rouge Parish. The samples were taken following harvest of the plant cane crop of the variety L 60-25 in 1970. The surface slope of the area was 3% and the soil varied from Loring silt loam on the upper portion of the slope (Replicate or Soil I), to Loring-Olivier silt loam (Replicate or Soil II) to Olivier silt loam on the lower portion of the slope (Replicate or Soil III).

Nine fertilizer treatments were established in each of the 3 replicates. Each plot consisted of 3 rows 35 ft in length. The center row in each plot was used for sampling and for yield data.

Composite root samples were obtained from 3 profile sites in each plot. Root samples from 0-6 in. and from below 6 in. to a depth of 24 in. in the row line and to a depth of 14 in. in the middle were collected separately. Stubble samples were collected by taking one-half of the stubble production from 12 stools in each plot. The cane was harvested by hand.

Root and stubble weights and nutrient element contents of roots and stubble are reported on a dry weight basis.

RESULTS AND DISCUSSION

Variables in the study, and cane, root and stubble yields are reported in Tables 1 and 2 and in Fig. 1.

It can be seen in Table 1 that differences in cane yield due to fertilizers were small and only one difference was significant. The effect of fertilizers on yield of plant cane in Louisiana is normally small, due probably to some improvement in soil fertility resulting from fallowing during the year preceeding the plant cane crop and to seedbed preparation practices (2). Root and stubble yields from the fertilizer treatments did not differ significantly when considered as pounds per acre nor when considered as pounds per ton of millable cane.

Table 1. The relationship of sugarcane yield due to fertilizer treatment, and quantity of roots and below-ground stubble.

No.	Fertilizer treatment (lb/a)				Cane yield (tons/a)	Below-ground production (lb/a)		
	N	P ₂ O ₅	K ₂ O	S		Roots	Stubble	Total
1	0	0	0	0	28.63	3100	603	3703
2	80	0	0	0	31.11	3630	602	4232
3	160	0	0	0	33.37	3900	600	4500
4	240	0	0	0	32.82	3440	680	4120
5	240	40	0	0	31.72	4070	580	4650
6	240	0	0	24	30.98	3060	780	3840
7	240	0	80	0	32.27	2970	737	3707
8	240	0	80	24	31.47	3550	663	4213
9	240	40	80	24	31.51	3110	648	3758
L.S.D. 0.05					4.48	N.S.	N.S.	N.S.

Differences in cane yield among soils (Table 2) were relatively large but differences in total production of roots and stubble per acre were small. When expressed as production per ton of millable cane (Fig. 1), root yields were of the order: Soil I > Soil II > Soil III. The weight of roots per ton of millable cane produced on Soil III was 30% lower than the weight produced on Soil I, whereas, cane yield on Soil III was 44% higher than on Soil I. The lower root production per ton of millable cane on the more fertile soils may explain part of the tendency toward a greater degree of lodging by cane grown on more fertile soils. The heavier above-ground growth and greater degree of lodging which normally occur on more fertile soils may be due to several factors but very little information is available concerning whether quantity and strength of roots may be related to lodging and to stubble damage of lodged cane during mechanical harvesting.

Table 2. The relationship of sugarcane yield due to soil variation, and quantity of roots and below-ground stubble.

No.	Soil Type	Cane yield (tons/a)	Below-ground production (lb/a)		
			Roots	Stubble	Total
I.	Loring sil	26.34	3450	561	4011
II.	Loring-Olivier sil	30.22	3310	650	3960
III.	Olivier sil	38.06	3520	753	4273
L.S.D. 0.05		3.29	N.S.	100	N.S.

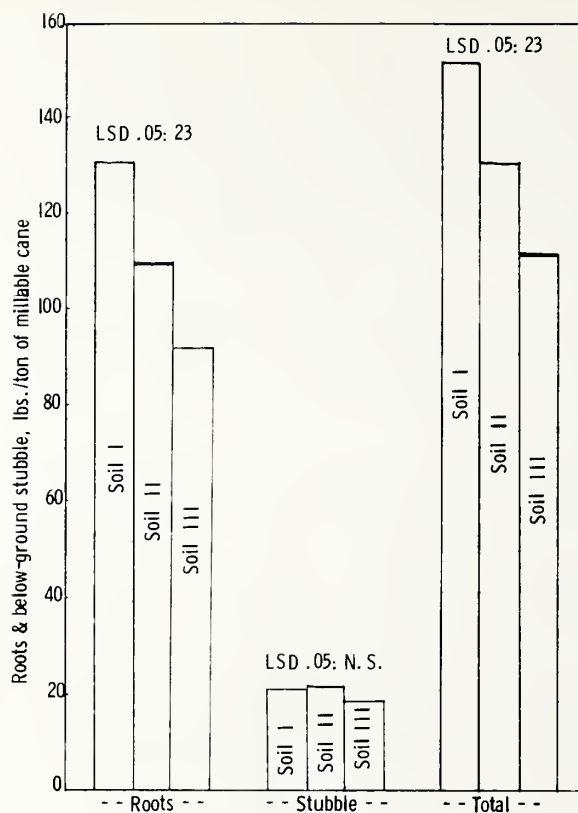


Fig. 1. The influence of soil variation on root and below-ground stubble production of sugarcane.

In the spring of 1970, the topsoil organic matter contents of Soils I, II and III were 0.81, 0.75 and 0.75%, respectively, or an average of approximately 15,400 lb of organic matter per acre was contained in the topsoil. The proportion of roots in the top 6 in. of soil did not differ significantly among Soils I, II and III and averaged 2,261 lb per acre or 66% of the total root production per acre. Calculations show that the average topsoil root and stubble content at harvest in 1970 was approximately 19% as large as the average organic matter content of the topsoil in the spring of 1970.

Differences in the contents of the major nutrient elements N, P, K, Ca, Mg, and S in roots and below-ground stubble were not significant. However, it can be seen in Fig. 2 that differences in nutrient contents of roots and stubble among soils, when expressed as pounds per ton of millable cane, were generally statistically significant and were of the order: Soil I > Soil II > Soil III.

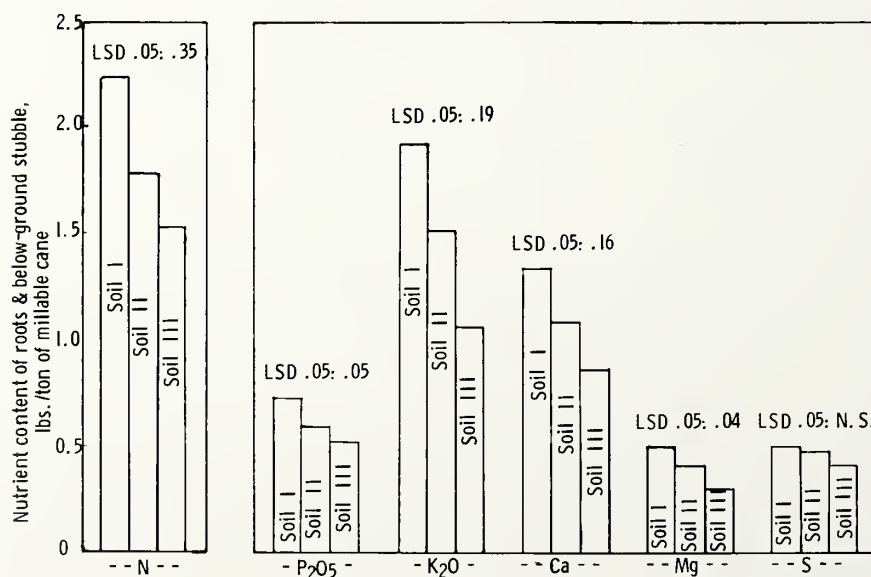


Fig. 2. The influence of soil variation on nutrient contents of roots and below-ground stubble.

The average concentrations of N, P (as P_2O_5), K (as K_2O), Ca, Mg and S in roots and stubble were 1.40, 0.20, 0.49, 0.36, 0.13 and 0.15%, respectively. In 1944, Borden (1) reported that N, P, and K concentrations in roots and stubble of sugarcane in Hawaii were 0.65, 0.29 and 0.55%, respectively. The higher concentration of N in roots and stubble found in this study may have been due in part to a higher rate of application of fertilizer N.

Table 3 contains correlation coefficients showing relationships among selected variables in the study. Highly significant negative correlations were found between cane yield and root weight per ton of millable cane and between cane yield and each of the macro-nutrients in roots and stubble per ton of millable cane. Cane yield was not significantly associated with stubble yield per ton of millable cane, but was positively associated with stubble yield per acre ($r = 0.652$). When considered on the basis of nutrient element contents of roots and stubble per ton of millable cane, highly significant positive correlations were found in all comparisons of macro-nutrients.

Table 3. Simple correlation coefficients among cane, root and below-ground stubble yields, and nutrient contents of roots and below-ground stubble.

	Roots	Stubble	Roots and Stubble	N	P (as P_2O_5)	K (as K_2O)	Ca	Mg	S
Cane (yield)	-0.654	-0.288	-0.693	-0.673	-0.661	-0.736	-0.546	-0.702	-0.529
Roots (yield)		-0.105	0.992	0.893	0.944	0.919	0.776	0.843	0.851
Stubble (yield)			0.020	0.162	-0.022	0.089	-0.071	0.035	0.021
Roots and stubble (yield)				0.918	0.946	0.935	0.771	0.852	0.858
N					0.903	0.886	0.742	0.708	0.847
P (as P_2O_5)						0.922	0.846	0.824	0.811
K (as K_2O)							0.775	0.897	0.800
Ca								0.770	0.707
Mg									0.641

From the data presented it appears that roots produced per ton of millable cane generally vary inversely with production of cane. This is in harmony with the results reported by Humbert (4).

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LEAF SHEATHS AND THE GERMINATION OF
YOUNG AXILLARY BUDS IN SUGARCANE

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ABSTRACT

Sugarcane supplied only with distilled water has been grown in the dark as large cuttings or as tops with several mature nodes. Because of the stored food, the shoots, especially of certain varieties, can grow and live for many weeks without sufficient light to turn the developing leaves from yellow to green. The buds from large cuttings may develop into a tillering stool, consisting of a mother shoot with growing axillary shoots, before growth finally ceases. The tops of Co 205, with leaf blades trimmed back, grow in length by the formation of new internodes and develop axillary shoots. These shoots tend to develop from the buds of older immature nodes when the sheaths from these nodes have been removed; when the sheaths are left intact, the axillary shoots tend to develop from mature nodes only. These results suggest that the sheaths may inhibit the germination of young buds where the nodes and internodes are roughly cylindrical (as near the top), but not where the nodes and internodes are very close together and like fulcrums of inverted cones (as at the base of the mother shoot).

Editor's note: Only the Abstract of this paper was available for the Proceedings.

ESTIMATING THE TOTAL LEAF AREA IN SUGARCANE VARIETIES

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ABSTRACT

Leaf-area estimates are useful in studies of pesticides, of borer parasites and predators, and of production efficiency when total leaf area is related to total land area. The total leaf area is the sum of the areas of individual green leaf blades on all stalks per unit of land. The direct measurement of individual leaf area, by planimetry or tracing, is accurate but slow. A faster, approximate method relates leaf area to leaf fresh weight. Differences between species caused the greatest variation in area per unit of weight; differences caused by leaf age, plant-to-plant variation, or among varieties of a species were relatively unimportant. The area per unit of weight for 29 hybrid varieties and 9 noble varieties of *Saccharum officinarum* L. averaged 0.3 dm²/g, for 10 varieties of *S. spontaneum* L. 0.4 dm²/g, and for species of the related genera, *Miscanthus*, *Narenga*, *Erianthus* and *Sorghum*, 0.5 dm²/g. The area per unit of weight constant for a variety multiplied by the total fresh weight of the blades gives the total leaf area.

INTRODUCTION

Because leaves convert carbon dioxide and water into the sugar stored in the cane stalk, the total leaf area of a cane field is directly related to yield. The ratio of leaf to land area is called the leaf-area index (LAI) and is often used as an indicator of efficiency in production or as an indicator of water-loss potential. Crops with adequate water but with a LAI less than 3 are inefficient, wasting both land and light. A leaf-area index of more than 7 may be inefficient, in that many older, shaded leaves use more energy than they store. An optimum leaf-area index is associated with maximum yields and is a useful criterion in developing new varieties or new cultural practices.

Leaf-area estimates are used in pesticide studies when leaf coverage by the chemical is important, or when the relation of droplet size or distribution to surface area is to be considered. Studies of borer predator and parasite populations involve leaf area as the total potential ovi-position sites for moths, and subsequently, as the area that predators and parasites must search to locate eggs or larvae. Cane growers appreciate large leaf areas, because this means more shading of the ground and better weed control, although a large leaf area can become a high trash content at harvest.

The area of individual leaves can be measured in a variety of ways (2). A planimeter, the standard instrument for determining the area of geometrically complex shapes, is often used to determine the area of small numbers of leaves. Planimetry is not conveniently adaptable to large numbers of leaves or to the large linear leaves of sugarcane. Leaf outlines can be made on blue-print paper, or can be traced on ordinary paper and the outlined area cut out and weighed. This weight, divided by the weight of a known area of the same paper, yields the leaf area. Approximately 1 hr is needed to determine the leaf area of 1 stalk of mature sugarcane. Electronic area indicators are available. These instruments cost up to several thousand dollars, require a power source, and are applied to each individual leaf. Although expensive, electronic area measurement is accurate and nondestructive.

Total leaf-area measurements for large samples or field plots are easiest if leaf area can be related to another, more readily determined character. The ratio of leaf area to leaf weight has been used for this purpose (1, 2).

MATERIALS AND METHODS

For all clones studied for variation in specific leaf weight, leaf samples were taken from mature stalks. All leaf blades from a stalk were removed, and the cut basal ends of the blades were immersed in distilled water. The leaves were transported to the laboratory and remained in water until they were removed, one at a time, blotted dry, and rapidly traced. The leaves were then weighed, and the leaf area was determined by dividing the weight of the outlined paper area by weight of a measured area of the same paper. The area per unit weight for each leaf was determined by dividing the area by the fresh weight of the leaf and expressing the quotient in dm²/g.

Plants of 29 clones of *Saccharum* hybrids were grown in a field of Mhoon silty clay loam in plots arranged in a randomized-block design with 4 replications. Data from this experiment were subjected to statistical analysis. Plants of 9 clones of *S. officinarum* were grown on ditchbank rows in Sharkey clay, and plants of 10 clones of *S. spontaneum* and 4 related genera were grown in 200-liter cans filled with Mhoon silty clay loam. These were not replicated and were not subject to statistical analysis.

^{1/} Research at this location is done in cooperation with the Louisiana Agricultural Experiment Station.

RESULTS AND DISCUSSION

Areas per unit of weight of the fresh leaf blades of 29 varieties of *Saccharum* hybrids averaged 0.3 dm²/g and ranged from 0.25 to 0.31 dm²/g (Table 1). The areas per unit of weight of these varieties were remarkably constant, and an analysis of variance showed no significant differences between varieties. Nor was there a significant difference between the oldest and youngest fully expanded leaves on mature stalks.

Table 1. Specific leaf weights (fresh) of clones of sugarcane hybrids, species, and related genera.

Clone	dm ² /g	Clone	dm ² /g
<u>Saccharum</u> hybrids		<u>S. spontaneum</u> L. varieties	
CP 65-332	0.25	SES 60-4-6	0.22
CP 67-349	0.27	SES 196	0.30
CP 29-120	0.28	SES 351	0.33
CP 60-16	0.28	Coimbatore	0.36
CP 66-357	0.28	Krakatau	0.38
CP 67-384	0.28	SES 6	0.40
L 65-69	0.28	SES 205-A	0.41
NCo 310	0.28	Djatirotto	0.42
POJ 213	0.28	Kinggoerang Oewis	0.46
Co 281	0.29	US 4639	0.51
Co 290	0.29	Mean	0.38
CP 66-346	0.29	Related genera	
L 60-25	0.29		
CP 28-11	0.30	<u>Erianthus bengalense</u>	
CP 29-116	0.30	(retz.) Hubb & Vaughan	0.40
CP 36-13	0.30		
CP 48-103	0.30	<u>Narenga porphyrocoma</u>	
CP 52-68	0.30	(Hance) Bor	0.43
CP 65-350	0.30		
CP 65-357	0.30	<u>Sorghum bicolor</u>	
CP 65-388	0.30	(L.) Moench	0.50
CP 66-315	0.30		
CP 66-321	0.30	<u>Miscanthus sinensis</u> Anderss.	
CP 67-407	0.30	(US 59-289)	0.53
CP 67-411	0.30		
CP 67-422	0.30	<u>Miscanthus hybrid</u>	
L 62-96	0.30	(US 64-53-2)	0.50
L 66-48	0.30		
CP 47-193	0.31		
Mean	0.29		
<u>S. officinarum</u> L. varieties			
Lahaina	0.28		
Otaheite	0.29		
Vellai	0.29		
Badila	0.30		
D-74	0.31		
Bandjarmasin Hitam	0.32		
Crystalina	0.32		
La. Purple	0.32		
La. Striped	0.33		
Mean	0.31		

The areas per unit of weight of 9 varieties of *S. officinarum* also averaged 0.3 dm²/g, ranging from 0.28 to 0.33 dm²/g (Table 1). The area per unit of weight of 0.3 dm²/g could be used for most commercial and experimental clones of the same age, growing under similar conditions.

The areas per unit of weight of 10 varieties of *S. spontaneum* averaged 0.4 dm²/g, but ranged from 0.22 to 0.51 dm²/g. Leaf morphology also varied in this group. The varieties US 60-4-6 and Coimbatore have very narrow leaves, the former having only vestiges of lamina. The varieties Krakatau and Kinggoerang Oewis have broad leaves, similar to those of the *Saccharum* hybrids.

The areas per unit of weight of related genera were slightly higher than those of *Saccharum*, averaging 0.5 dm²/g and ranging from 0.40 to 0.53 dm²/g. While US 60-4-6 had the most narrow leaves and the lowest area per unit of weight, the leaves of sorghum were the widest, with nearly the highest area per unit of weight. This suggests that area per unit of weight may be related to leaf width and thickness,

or to the ratio of water to air space within the leaves. Data in Table 2 show little relation between area per unit of weight and moisture content, or between area per unit of weight of fresh and dry leaves.

Table 2. The relation of percent moisture to fresh and dry specific leaf weights.

Clone	Specific leaf weight		Percent moisture
	Fresh	Dry	
CP 65-332	0.24	1.19	73
CP 28-11	0.32	1.04	70
CP 66-315	0.32	1.02	69
La. Purple	0.32	1.19	73
POJ 213	0.32	1.17	73
Krakatau	0.36	1.12	68
SES 196	0.38	1.01	62
Djatiroto	0.40	1.10	64
US 4639	0.48	1.34	64
Kinggoerang Oewis	0.49	1.46	66

Since area per unit of weight showed little variation, it is permissible to use a constant ($0.3 \text{ dm}^2/\text{g}$) for varieties commonly encountered in commercial or experimental fields. The area per unit of weight could then be used in determining total leaf area by using the formula:

$$A = SW,$$

where A is the total leaf area, S is the area per unit of weight ($0.3 \text{ dm}^2/\text{g}$), and W is the weight of leaf blades (g). A 0.0247 ha (0.01 acre) plot of cane that contained 300 stalks is typical of Louisiana fields. A 10-stalk sample may yield leaves weighing 980 g. The formula above would give an area of 294 dm^2 of leaves for the 10 stalks, or $88,200 \text{ dm}^2$ or 882 m^2 for the plot, or 3.6 ha of leaves/ha of land.

Caution should be used in applying the value shown for area per unit of weight to cane leaves from other soil types or other stages of growth. Changes occur in the relation of leaf area to leaf weight in different growth stages (1). When using fresh leaves for determinations of area per unit of weight, care must be used to avoid errors caused by changes in water content.

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FLORIDA SUGARCANE ATTACKED BY WHITE GRUBS IN 1972

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ABSTRACT

During late August and early September, near-mature sugarcane plants were observed dying and falling over as a result of the destruction of their roots by a large white grub identified as Eothymus subtropicus. The size of affected areas varied from a few square yards to entire 20-acre fields. Good control was obtained by field flooding continuously for 144 hr.

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MASS REARING THE SUGARCANE BORER

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ABSTRACT

A facility has been developed at the Houma Station for mass-rearing of the sugarcane borer, (*Diatraea saccharalis* (F.)), on an artificial diet under controlled conditions. After the eggs are laid and hatched, the first instar larvae are transferred to individual compartments (1.25 x 1.25 x 3.75 cm) of a partitioned tray (30 x 60 x 2.5 cm) which have been filled two-thirds full of a prepared pinto-bean diet. The trays are then closed so that each compartment is sealed with bronze screen and polyurethane foam padding. The closed unit is placed in a controlled temperature room at 29 C. After 25 days the trays are opened and the pupae are transferred to vented containers for emergence. The moths are collected with a power aspirator into cylindrical cages lined with wax paper. The moths oviposit eggs in masses on the wax paper liner. The eggs are collected daily by changing the liners and punching out 1.25 cm disks of the paper with an egg mass adhering to each disk. The eggs are held in controlled environment at 26-27 C and 85-95% RH until they are ready to be used for plant-resistance research, rearing parasites, parasite-host interaction studies, or to rear more moths for the parent culture or for irradiation research. In a 4-week period, 200,000 egg masses can be produced using one 8 x 12-ft and two 8 x 8 controlled temperature rooms, one 8 x 12-ft diet preparation room and one 12 x 13-ft work room.

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L 60-14, A TROPICAL SUGARCANE VARIETY

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ABSTRACT

The variety L 60-14 was introduced at Ingenio San Antonio, Nicaragua, Central America, in 1965. Small plot tests demonstrated its possibilities as an early-to-medium cane. It was increased commercially in 1970-1971. In 1971-1972, it averaged 45.7 tons to the acre on 3,378 acres and 49.1 tons per acre on 5,598 acres through March 20, 1972-1973. Average yields of all fields at the Ingenio were 42.6 tons in 1971-1972 and 44.9 tons in 1972-1973 through March 20. Estimated sugar recoveries by use of crusher juice analyses through March 20, 1971-1972 and 1972-1973 were 209.39 pounds and 192.02 pounds for L 60-14. Estimated sugar recoveries of all varieties were 205.40 pounds of sugar per ton of cane in 1971-1972 and 190.25 pounds of sugar per ton of cane in 1972-1973 during the same period. L 60-14 appears to be a good early-to-medium (November-February) variety for tropical areas. It is planned to increase this variety to 9,600 acres of a total 20,000 acres for the 1973-1974 harvest.

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EFFECT OF FROST ON CERTAIN SUGARCANE VARIETIES GROWN
IN THE LOWER RIO GRANDE VALLEY OF TEXAS

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ABSTRACT

On Jan. 12 and 13, 1973, temperatures dropped to 26 and 29 F, respectively, killing the meristems of sugarcane planted in the Rio Grande Valley of Texas. Eye damage was moderate to severe on 6 of the 7 varieties selected for commercial planting, but little damage was caused to the lateral buds of the seventh variety, NCo 310. Juice data indicated that the peak recoverable sugar measured in 18 varieties under evaluation occurred prior to the chilling period with 245 lb/T. After the frost, recoverable sugar gradually decreased to 200 lb/T by Mar. 12. A second period of frost of similar intensity occurred on Feb. 9 and 10, and most of the lateral eyes of the 6 varieties, which had been stimulated to germination, were killed, and planting material became largely unavailable. Three of the varieties included in these studies showed evidence of rapid deterioration in juice quality following the second freeze, as measured by disappearance of sucrose and an apparent increase in ash % solids.

INTRODUCTION

The new sugarcane industry in South Texas faces certain problems such as optimum use of water and some saline soils, both of which man has learned to cope with and control. One other that is common to the sugarcane areas of the continental USA, but beyond man's control, is sub freezing weather.

A high probability of severe and early freezes limits the sugarcane processing season to about 65 days in Louisiana, but the reduced incidence of these conditions permits a longer processing season in Florida. The winter climate in the lower Rio Grande Valley of Texas more closely resembles that of Florida than that of Louisiana. Nevertheless, severe winters can be expected in South Texas, and while the probability of extreme minimum temperatures is somewhat less than in the cane area of Florida, the lowest recorded temperature of this area of Texas is lower than that reported from the Florida cane area, and severe freezes in Texas have been of longer duration.

Of several factors that determine the extent of freeze damage to cane, two of the most important are intensity and duration of the freeze. A third, which man can control to some extent, is the selection of varieties that are more cold tolerant and thus remain more millable following moderate freezes.

The effects of light freezes on sugarcane are well known (5, 6, 7, 8). Indications are that freezes which kill leaves, apical meristems, and the upper lateral buds essentially stop the photosynthetic processes but cause only slight deterioration in the quality of the cane juice. The occurrence of temperatures of 26 to 29 F on Jan. 12 and 13, and again on Feb. 9 and 10, provided an opportunity for evaluation of the effects of mild freezing conditions on a sugarcane nursery in the Lower Rio Grande Valley of Texas, which included the 7 varieties selected for commercial planting in this area and several newer varieties.

METHODS

On Monday following the frost of Jan. 12 and 13, selected varieties were cut, stripped and divided into top, middle and bottom sections of the stalks. Borer-damaged eyes were rejected, and the remainder were placed in tubs containing a mixture of 1 1/2 bags of soil conditioner to 1 bale of peat moss. After watering, the tubs were maintained at 65 F in a greenhouse. Sprouting of eyes was recorded weekly for a period of 2 months, and percent germination of eyes noted.

For studies of juice quality, 20-stalk samples of each variety were passed once through a 3-roll, cane-sampling mill hydraulically loaded to provide a pressure of 30-33 tons of force on the upper roll. Extracted juices were screened through a 100-mesh screen, mixed, weighed, and sampled. Analyses of the crusher juices were conducted according to standard methods of the sugarcane industry, including spindle brix readings of solids content, polarization of a 26-g sample, and free acidity values as ml of 0.1 N NaOH required to titrate 10 ml of juice to pH 8.3. Free acidities were also expressed as % aconitic acid on brix solids, since there was evidence of the disappearance of juice solids in some materials. Carbonate ash was determined according to Method I of the AOAC (1), except for ignition at 550 C instead of 525 C, and the weight of ash was expressed as % on brix solids. Apparent purities were calculated values where sucrose, as measured by polarization, was expressed as % on brix solids.

RESULTS

Germination of Lateral Eyes.

The effect of the Jan. frost on the viability of lateral eyes was determined on the following varieties: CP 44-101, CP 52-68, CP 55-30, CP 61-37, L 60-25, L 62-96 and NCo 310, as these are the commercial canes selected for the first milling season in Texas.

The variety NCo 310 had outstanding tolerance to frost, with an overall 93% germination of lateral eyes on the entire stalk (Table 1). In general, top eyes were more severely damaged than bottom eyes; thus, the percent germination for CP 44-101 was 36.9, 64.2 and 89.1% from the top, middle and bottom thirds of the stalks respectively. The buds of the varieties L 62-96, CP 55-30 and CP 52-68 were particularly susceptible to cold injury, with the latter variety showing only 24.5% viable eyes.

Table 1. Percentage germination of lateral eyes on stalks of 7 sugarcane varieties following frost.

Variety	Portion of Stalk			Overall
	Top 1/3	Middle 1/3	Bottom 1/3	
NCo 310	98.1	90.4	91.2	93.3
CP 44-101	36.9	64.2	89.1	63.9
L 60-25	32.6	76.7	73.1	58.2
CP 61-37	79.3	21.1	36.8	50.3
L 62-96	37.7	28.6	54.8	39.2
CP 55-30	31.5	36.7	50.6	39.2
CP 52-68	12.1	12.5	44.7	24.5

Effect of Freeze on Estimated Recoverable Sugar.

Certain varieties had been selected previously to determine their ripening characteristics. One group of 9 varieties, together with NCo 310, was harvested on Oct. 30 and every other week until Mar. 19. A second group of 9 varieties, and NCo 310, was harvested on alternate weeks.

Analyses of the crusher juices obtained from the monthly harvests of the 20 sugarcane varieties revealed that 13 maintained juice purities of 80% or higher during the 5-month harvest period. The trials were not designed with sufficient replications to allow reliable month by month evaluation of each variety, but the averages of the monthly analytical data for each variety (Table 2), afforded means for comparing the performances of these canes under the conditions prevailing during this period. The varieties are listed in Table 2 in the order of decreasing average crusher juice purities. Except for L 66-48 and CP 62-374, where brix, pol, and purity showed no significant change throughout the harvest period, the juices of most varieties indicated that some degree of deterioration had occurred by the time of Feb. or Mar. harvests, so that averaged values of brix, pol and purity in this table were slightly less than the maximum levels detected.

Table 2. Seasonal average crusher juice composition for 13 sugarcane varieties exhibiting minimal response to frost damage.

Variety	No. harvests	brix	pol	purity	Free acidity	Carbonate ash (% bx)
CP 57-614	4	21.99	19.2	87.5	2.14	3.52
L 64-1	5	19.83	17.3	87.4	1.46	3.74
L 62-96	5	19.68	17.0	86.4	1.65	3.94
CP 56-59	6	19.68	17.0	86.1	1.36	3.64
CP 61-37	6	18.71	16.0	85.7	1.83	3.85
L 66-48	5	18.80	16.0	85.2	1.90	3.89
CP 65-357	6	19.54	16.6	84.7	2.00	4.50
L 61-52	5	18.37	15.6	84.7	1.57	4.54
CP 59-73	6	19.34	16.4	84.6	2.10	4.33
L 60-14	5	20.11	17.0	84.6	2.28	4.01
L 61-43	5	19.52	16.5	84.5	2.23	4.45
L 66-15	5	18.75	15.7	83.7	1.36	4.30
CP 60-1	5	18.84	15.7	83.4	2.27	4.79
CP 62-374	6	18.06	14.8	82.0	2.11	4.62

The free acidities (Table 2) showed no particular correlation with other data. Values taken at the monthly harvests of each variety were reasonably constant throughout the 5-month period, and tend to reaffirm the observations of Fort and McKaig (2), and Irvine (4) that the acidities of cane juices reflect varietal response to environmental factors.

Carbonate ash values (Table 2) were noted to be generally higher for the varieties which provided lower purity juices. With some of the varieties listed, the higher ash contents may reflect failure of the cane to reach maximum maturity, but with the higher purity varieties, the ash contents, no doubt, represent varietal response to the environmental factors, as noted by Fort and McKaig (2).

Three of the cane varieties in these trials, L 65-69, L 62-86, and L 64-67, exhibited marked responses to freezes, as measured by brix, pol, and purity decreases at the time of the Mar. harvest. Analytical data from these varieties are presented in Table 3, where the first line for each variety provides average data for all harvests prior to Mar., and the second line the data from Mar. harvest only. Small decreases had been detected in brix, pol, and purity values for each variety by the time of the Feb. harvest, but all purities still exceeded 80%. By Mar., however, juice deterioration had become significant, L 65-69 to the greatest degree, followed by L 62-86, and to the least degree L 64-67. The type of deterioration noted with the 3 varieties reported in Table 3 did not involve fermentation, and the free acidity values showed no significant increase between Feb. and Mar. harvests.

Table 3. Seasonal average crusher juice composition for 3 sugarcane varieties exhibiting measurable response to frost damage.

Variety	No. Harvests Averaged	Brix	Pol	Purity	Free acidity	Carbonate ash (% bx)
L 65-69	5	19.49	15.9	81.6	2.48	4.99
	1	13.32	9.4	70.6	2.27	7.95
L 62-86	4	18.54	15.7	84.4	1.49	4.96
	1	14.76	11.5	77.9	1.88	6.24
L 64-67	4	18.61	15.4	82.8	2.14	4.76
	1	16.49	13.0	78.8	2.03	5.91

Juice carbonate ash content of the 3 varieties in Table 3 for the period prior to the Mar. harvest were generally higher than those listed in Table 2, and the significant increases which occurred by the time of the Mar. sampling date indicated that the loss of brix solids was principally a loss of organic matter, such as sucrose.

Data from juice analyses were used to calculate pounds of recoverable sugar per net ton of cane, which are presented in Fig. 1 as a statistically derived quadratic equation for all varieties taken together. In the latter, x represents tenths of a week and the whole expression is given in logarithms to the base 10. The variety NCo 310 was deleted from these data since there was considerable rat damage to the stalks.

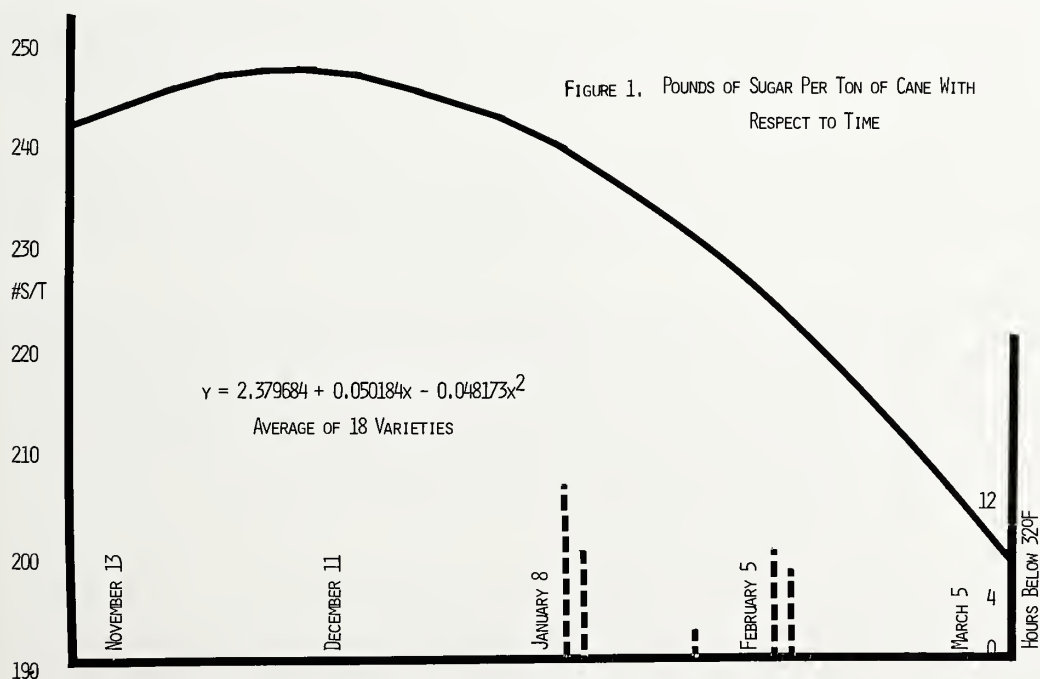


Fig. 1. Pounds of Sugar Per Ton of Cane With Respect to Time.

The frost periods of Jan. 12-13 and Feb. 9-10 decreased the overall recoverable sugar of the 18 varieties from peak values exceeding 240 lb per ton in late 1972 to 200 lb per ton by Mar. 12. Data in Table 4 indicate that the varieties CP 65-357, L 62-96, L 60-14, L 66-48, and L 64-1 appeared to have especially good keeping quality, but L 64-67, L 62-86, and L 65-69 appeared to be poor in this respect. Although the data for CP 57-614 and CP 57-603 were less complete, they indicated that these varieties had good tolerance to cold.

Table 4. Pounds of sugar per net ton of cane at several dates of sampling.

Variety	Date					
	10/30/72	11/27/72	12/18/72	1/22/73	2/19/73	3/19/73
CP 57-614	284.0	292.8	281.7	274.4	---	---
CP 57-603	---	---	---	---	211.8	246.2
CP 65-357	238.6	242.1	261.3	235.4	237.2	224.7
L 62-96	258.0	277.1	273.4 ^a	259.2	230.9	220.5
CP 59-73	257.7	246.4	252.3	237.7	219.8	209.3
CP 61-37	234.4	256.6	248.3	234.4	221.0	208.7
CP 56-59	257.0	277.3	262.5	265.2	221.3	203.4
CP 62-374	199.7	236.3	223.9	183.6	222.7	201.1
CP 55-30	199.5	191.4	193.4	192.0	179.4	149.4
L 65-69	221.3	231.1	241.8	232.0	204.9	122.4

^a 12/11/72

Variety	Date				
	11/13/72	12/11/72	1/8/73	2/5/73	3/5/73
L 60-14	263.1	248.3	258.5	228.4	234.7
L 66-48	238.8	227.1	243.4	233.3	223.1
L 64-1	271.1	264.3	271.5	250.0	220.0
L 61-43	254.0	251.6	251.7	220.3	216.9
L 66-15	245.1	209.0	233.7	235.3	205.7
L 61-52	238.2	226.6	240.9	221.0	201.1
CP 60-1	251.6	244.8	240.1	210.3	186.0
L 64-67	228.9	229.1	220.1	204.4	181.3
L 62-86	222.6	231.9 ^b	227.3	186.9	159.3

^b 12/18/72

DISCUSSION

Low temperatures such as those experienced in the winter season of 1972-73 were unusual for the Lower Rio Grande Valley of Texas and had not occurred since 1963, when minimums of 27 and 23 F were recorded on the 13th and 24th of Jan., respectively. Such temperatures would probably mean that most seed cane would be unsuitable for planting. This farming operation can not be delayed without risk of poor stands and loss of viable seed.

In 1973, the temperatures were recorded at a height of 5 ft. Since the frost had been preceded by rainy weather, the moisture on the ground undoubtedly had a mitigating effect on cold air temperatures at ground level. Although the bottom eyes of most varieties can be assumed to be more tolerant to cold than those near the top, a cold spell could be expected to be more injurious during a dry spell than when conditions are moist.

A variety such as NCo 310, which tends to lodge easily, may be less exposed to low temperatures that hover a few feet above the ground. Coleman⁽¹⁾ observed in Louisiana that frost damage was greater in lodged cane under dry conditions due to loss of protection by the leaf canopy. Nevertheless, there seemed to be real differences among varieties in susceptibility to damage by cold. Thus, the bottom third of the stalks of NCo 310 and CP 44-101 had more viable eyes after the freeze than stalks of CP 55-30 and CP 52-68. This was also borne out by the experience of growers who were forced to plant late. Data for the variety CP 61-37 showed good viability in the top third of the stalks and poor in the remainder. None of the canes had been sprayed against the borer and infestation was especially heavy in this variety, a factor which undoubtedly contributed to poor germination.

(1) Private communication. R. E. Coleman, U.S.D.A., A.R.S., Beltsville, Maryland

The cold weather that can be expected at latitudes of 28 to 32° on either side of the equator, accentuates the need for early-maturing cane varieties. Generally, recoverable sugar of most varieties of sugarcane grown in these latitudes will not peak out in Mar. or Apr. So far, no varieties have indicated this in the Lower Rio Grande Valley of Texas. In Iran, the purities of juices from commercial varieties did not peak out until May, when they reached 92 to 93% with brix values over 20.

The selection of cane varieties with a significant degree of cold tolerance also would be important from the standpoint of factory performance. Deterioration in juice quality, similar to that observed with L 65-69, L 62-86, and L 64-67, would seriously impair sugar production, since the yields of recoverable sugar, as indicated by purities in the 70s, would be at the level of marginal practicality, and these yields would be further decreased by the higher ash levels.

The type of curve illustrated in Fig. 1 indicated a peak before the frost, but the regression nature of the quadratic equation was influenced greatly by the data obtained after the Jan. and Feb. frosts.

A variety program should be based on testing clones of sugarcane in the area where they are to be grown; in the latitude of the Lower Rio Grande Valley, tolerance of cold is very important in the selection. Varieties such as CP 57-614, CP 57-603, CP 65-357, L 60-14, and L 66-48, which appear to show some degree of tolerance to frost, should be evaluated thoroughly. On the other hand, varieties such as CP 55-30, L 65-69, L 64-67, and L 62-86 may not be suitable in Texas.

Irvine (4) has recommended caution in the use of juice free-acidities in gauging the extent of post-freeze damage to sugarcane because these acidity values vary in response to variety and environment. He suggested that measurement of the gum content of juices from freeze-damaged canes would provide a more reliable index of the extent of deterioration of the cane juice since this juice constituent has been found to increase in severely frozen canes (3). Gums were not measured in the studies reported here, and examination of the free-acidities reported in Table 3 indicated that these values do not provide a reliable indication of the extent of juice deterioration which could occur after mild freezes. Where juice brix levels changed as greatly as those for L 65-69 and L 62-86, expression of free acidities as ml of alkali for titration of a specific volume of juice to pH 8.3 seems to be ineffective for detecting the degree of deterioration from frost. If the juice titers, as reported in Table 3, were calculated as acetic acid and expressed as % on the brix solids of the juice, a significant change in acidities could be detected. Acidity % brix solids for L 65-69 prior to the Mar. harvest averaged 0.68%, and at the Mar. harvest, 0.94%. Similar values on L 62-86 were 0.48% prior to Mar., and 0.70% at the Mar. harvest. No significant change in the L 64-67 juices were detectable by calculating acidities to the solids basis, doubtless because of the small change in juice solids content. This means of expressing juice acidities would provide a more satisfactory indicator of the sort of chemical changes noted in Table 3 following mild freezes than the customary use of titers, but it seems doubtful whether acidity measurements of either sort would accurately indicate the extent of gum formation following more severe freeze damage.

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PAPERS PRESENTED AT MEETING OF FLORIDA DIVISION

October 11, 1973

MULTIPLE-EFFECT EVAPORATION:
A SIMPLIFIED METHOD OF CALCULATION

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This simplified method of calculating multiple-effect evaporation is based on the first of Rillieux's principles. We have used the method in checking existing installations and in designing modifications to multiple-effect evaporators with successful results, and for engineering purposes it has proved to be accurate enough. We do not say that this is a better method than a standard heat balance, which should be more accurate, but we have tried both methods several times and the results were not too different.

The advantage we have found in using our simplified method is that it is flexible, and due to its simplicity, gives us an opportunity to experiment with different arrangements so we can choose the best to give us the most efficient combination of evaporators, pans and juice heaters.

From the first of the Rillieux principles, we can assume that 1 lb of steam or vapor applied to the calandria of an evaporator body will produce 1 lb of evaporation on the juice side of the body. This principle has been discussed frequently, and we will not try to discuss it further in this paper, but we would like to point out that, when the difference between the incoming juice and the juice inside the first body of an evaporator without a clarified juice heater is within 20 F, the results of this method compared with the results of a heat balance are very close.

In case of a difference in temperatures larger than 20 F, you can figure a factor $\frac{T_1}{T_2}$, which, when multiplied by the amount of steam fed to the evaporator, will give you the amount of vapor transferred from the first body to the rest of the system. In calculating this factor, T_1 equals the temperature of the incoming juice in degrees F, and T_2 equals the temperature of the juice side of the first body in degrees F.

If a more accurate factor is needed, the formula $\frac{WC(T_1-T_2)}{L}$ can be used. Here, W equals the weight of the juice in lb/hr, C equals specific heat, (.96 for juice at 16-17 brix, T_2 equals the temperature in degrees F on the juice side, T_1 equals the temperature in degrees F of the incoming juice, and L equals latent heat (hfg) at the temperature of the juice side in the first body from the steam table. This will give you the amount of exhaust steam needed to bring the incoming juice temperature up to the juice side temperature. Deducting this figure from the lb/hr of exhaust fed to the calandria, will give the amount of vapor transferred from the first body to the rest of the system.

Perhaps the best way to explain this method is by means of an example. Let us apply the method to a quadruple effect that is the evaporating system in a sugarhouse that grinds 5,000 tons per day. The mixed juice brix is 16, and the syrup brix is 61. The exhaust steam production is 212,000 lb/hr, and is distributed as follows: 63,000 lb/hr to the pans, 16,500 lb/hr to the secondary juice heaters, and 4,000 lb/hr to the clarified juice heaters, leaving 128,000 lb/hr to the first body of the evaporators (Fig. 1).

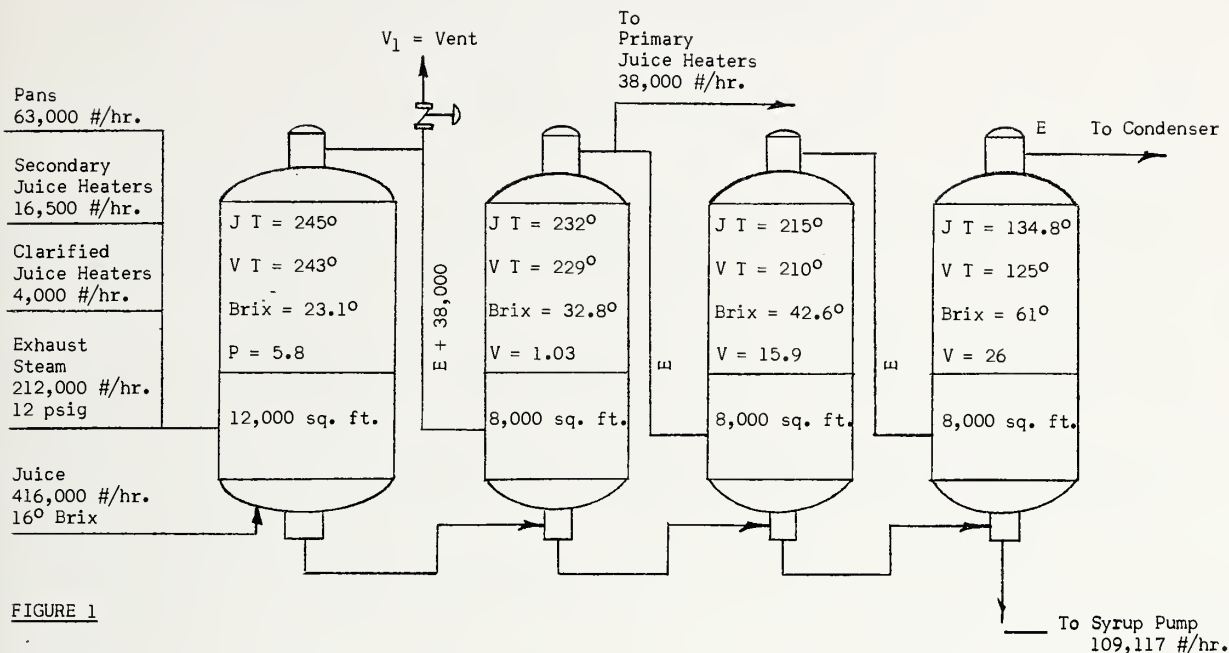


FIGURE 1

$$306,883 = V_1 + 4E + 38,000 + 38,000 \quad A$$

$$128,000 = V_1 + E + 38,000 \quad B$$

Subtracting B from A,
178,883 = 3E + 38,000

$$\therefore E = \frac{140,883}{3} = 46,961 \text{ #/hr.}$$

Substituting this value in equation B,
 $V_1 = 43,039 \text{ #/hr.}$

J T = Juice temperature (affected by boiling point rise)
V T = Vapor temperature
E = Evaporation in quadruple effect
P = Pressure
V = Vacuum, inches of mercury
 V_1 = Vent #/hr.

Fig. 1. Diagram to illustrate method of calculating multiple effect evaporation.

The pounds of juice to be processed are 416,000 lb/hr, (at 100% mixed juice extraction.) The evaporation is 73.77% for the system, and the amount of water to be evaporated is 306,883 lb/hr. In the analysis of this quadruple effect, there are two equations with two variables, which will be easily solved.

The first equation will take into account the evaporation of the system; the second equation will balance the steam input to the first evaporator with the output (vapors) of the first body.

The amount of vapors vented to the atmosphere, as calculated in lb/hr, is an average value and not an instantaneous value. The variation in the amount of vapor vented is due to the operational sequence of the vacuum pans. The 63,000 lb/hr of exhaust steam fed to the pans is another average value provided by an integrator.

Theoretical figures calculated for the pressures and temperatures, assuming equal drops of pressure in each evaporator, differ from the actual readings given by the gauges (Table 1). This is due to the bleeding of vapors in the first and second evaporators, (vent and primary heaters,) and the difference in heating surfaces between the first and second evaporator bodies. This assumption should be true for equal heating surfaces and no vapor bleeding.

Table 1. Tabulation of data.

	Lb/hr		Brix		Lb/sq in.		% Evaporation	
	A	B	A	B	A	B	A	B
Juice		416,000		16				
Syrup	109,117			61				
Exhaust		212,000				12.0-13.0		
Total evaporation	306,883						73.77	
Exhaust to pans		63,000				12.0-13.0		
Exhaust to secondary juice heaters	16,500					12.0-13.0		
Exhaust to clarified juice heaters	4,000					12.0-13.0		
Vapors to primary juice heaters	38,000				* 1.03 V	1.0- 1.2		
First evaporation						4.5- 5.0		
Second evaporation					* 1.03 V	1.0- 1.2		
Third evaporation					*15.9 V	12.0-13.0 V		
Fourth evaporation					*26.0 V	26.0 V		

A - Calculated; B = Gauge, flowmeter or instrument; V - Inches of mercury.

* Calculation of this pressure was obtained assuming an equal drop through each evaporator. This is not entirely true when you have vapor bleeding.

In case you only need to know the amount of exhaust steam needed for the multiple effect evaporator, you can find it by making $V_1 = 0$ in equation A, and solving for E. If you substitute this value in equation B, you will have:

$$\underline{A} \quad 306,883 = 4E + 76,000 \quad V_1 = 0$$

$$\therefore E = \frac{230,883}{4} = 57,720 \text{ lb/hr}$$

$$\underline{B} \quad W_E = E + 38,000 \quad V_1 = 0$$

$$W_E = 57,720 + 38,000$$

$$W_E = 95,720 \text{ lb/hr}$$

$$W_E = \text{lb/hr exhaust steam}$$

This amount, $W_E = 95,720 \text{ lb/hr}$, gives the exhaust needed to have the 306,883 lb/hr of evaporation in the system, corresponding to juice at 16 brix and syrup at 61 brix.

This is a good point at which to start with a final heat balance, so that without too much trial and error, you can find the amount of exhaust steam needed.

Thus, you can see the advantage in using this simplified method of calculating multiple effect evaporation in the preliminary stages of designing the best arrangement of your juice heating and evaporating equipment.

CONDITIONS AFFECTING THE LOW GRADE WORK IN A CANE SUGAR FACTORY

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The technical literature on conditions affecting the exhaustibility of final molasses in a cane sugar factory is very extensive. As far back as 1893, Prinsen Geerligs (4) suggested that the ratio of reducing sugars to ash should be used in judging the quality of a molasses. A molasses in which this ratio is high can be exhausted to a greater extent than one in which it is low, meaning that inorganic salts tend to increase the solubility of sucrose while reducing sugars decrease the solubility.

Michely and De Gyulay (1) found that under the condition of their experiments, only concentration had any effect on the exhaustibility of final molasses. They proposed impurity-water ratio as a basis to judge the work of a low grade station, considering impurity as total solids by drying minus sucrose. Through their test, they found that the relationship between the purity of an exhausted molasses and the impurity-water ratio is linear, a higher ratio conveys higher exhaustion of molasses.

To judge the effect that the two mentioned ratios have on the minimum attainable purity of a final molasses in Florida, information was compiled from the 1972 and 1973 crops showing the results plotted on the scatter diagrams, Fig. 1 and 2.

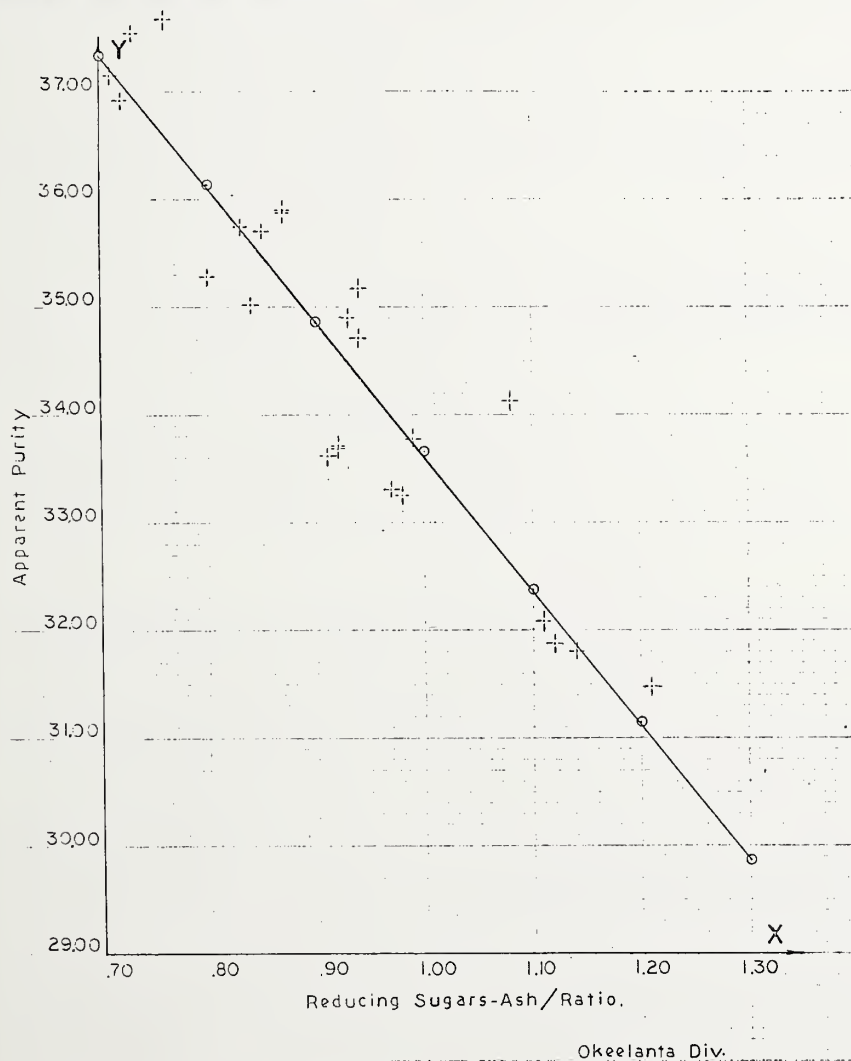


Fig. 1. Scatter diagram of apparent purity vs reducing sugar-ash ratio.

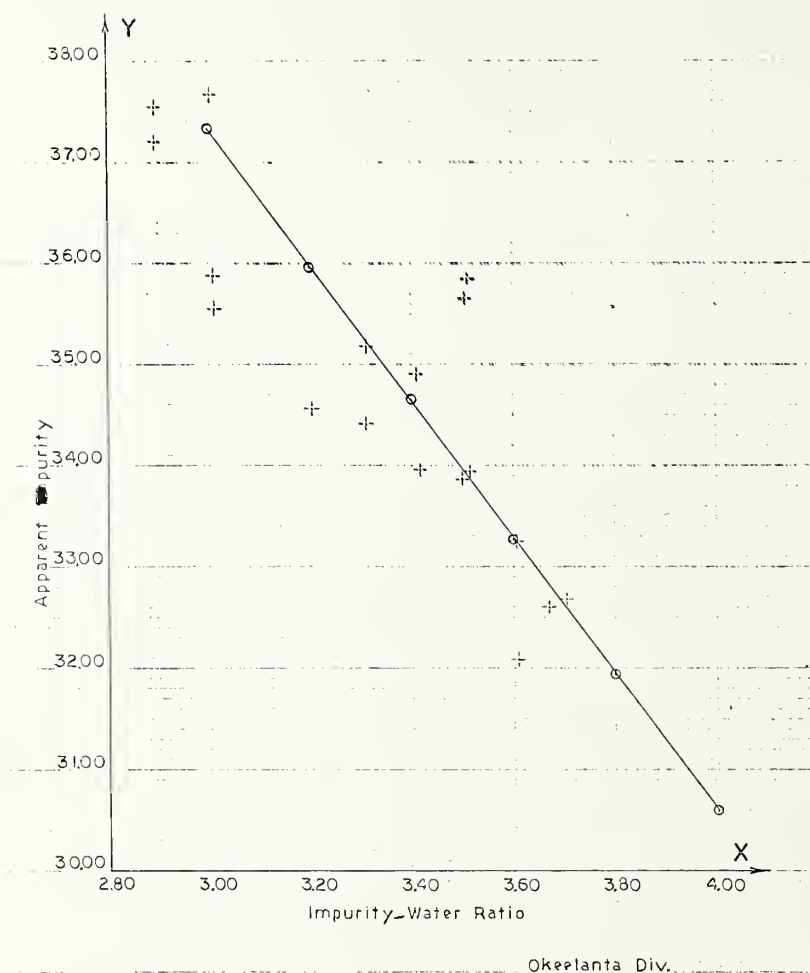


Fig. 2. Scatter diagram of the relationship between apparent purity and the impurity-water ratio.

PAN FLOOR WORK

The daily routine in a boiling house has a great deal to do with its performance. The pan work is fundamental to achieve a good exhaustion at the crystallizer's end. The poor handling of the material in stock cannot be corrected by a good performance of the low grade crystallizers.

The selection of a boiling system to operate the pan floor of a sugar house is a prerogative of the technologist in charge of manufacturing. The use of the conventional three boiling system with 80-70-58 massecuite purity has diminished considerably and the old two boiling system 72-58 massecuite purity has become an obsolete procedure.

At present, with the improvements made on instrumentation for controlling and indicating the vacuum pan operations, it is very simple to take advantages of the full-pan seeding-technique. This technique has led to several improved systems of operation yielding commercial sugar of much better quality and also increasing the efficiency and the capacity of the pan floor.

The ideal boiling system would be one that could crystallize the sucrose available in the syrup in one stage, yielding commercial sugar of a standard quality and well exhausted molasses. So far this has not been accomplished. The next best system to the one boiling system of operation would be a boiling system which could get the same results with the least number of stages. For several years the author had the opportunity of operating a pan floor using a variation of the conventional three boiling system in which

the purities of the massecuite were kept in the range of 85-75-60. This modus operandi has been called the new three boiling system (9) and sometimes also as the 2 1/2 boiling system (6). The procedures on how to carry out the pan-floor operations with these systems are pretty well known.

More recently, the improved two boiling system (1, 2, 3) was introduced taking advantage of better designed equipment, particularly crystallizers for commercial massecuites with heat exchange elements in which the ratio of cooling surface to massecuite volume has been substantially increased. This system of operation allows a complete desugarization from syrup to final molasses in two stages, representing a tremendous improvement from a technological point of view.

The commercial sugar made from one type of high purity boiling is quite uniform, avoiding not only different sugar quality but also the extra load on equipment and heat balance when B sugar is used as seed for the commercial boiling (5, 8).

FUNDAMENTALS

The fundamentals of a well-managed low-grade station could be listed as follows:

1. Any successful system of operation must start with a suitable graining of a footing to boil the low-grade strike. The individual crystals should be free to conglomerate and twins; any irregularity should be considered undesirable. Due to the slow rate of crystal growth, this ideal condition is more likely found when low purity material is used as footing. As long as the rate of crystallization is greater as the surface area of sucrose crystals per unit volume is larger, it is considered that the smaller the size of the crystals the more the molasses can be exhausted. This, of course, has its limitation, which is related to the capability of the low-grade centrifugal station to handle small size crystals. To achieve repeatable operations, the vacuum pan doing the graining should be equipped with automatic controllers to regulate as much as possible the crystallization process.

2. The final concentration of the strike should be carried to the maximum workable consistency. Since the degree of supersaturation of the mother liquor is the driving force for crystallization, it is imperative that the strike be finished as tight as the equipment can handle it. Today, with the help of surfactants, the final brix of the low-grade strike could be increased substantially. Due to its excellent circulation, vacuum pans equipped with a mechanical circulator are the most suitable to carry the strike to a high consistency.

3. Once the strike is finished and discharged into the low-grade crystallizers its temperature should be brought down to 100-105 F. Much can be accomplished by a continuous circulation of the massecuite throughout a series of crystallizers equipped with heat exchange elements. A reduction of 4-6 F per hour is obtained when cooling water 78 F is used. To get an adequate rate of flow the addition of a surfactant is advisable. The use of water on top of the massecuite to reduce viscosity should be avoided completely.

4. When the target temperature is reached, the velocity of crystallization diminishes to the point where it is not feasible to exhaust the mother liquor any further. The next step is then the re-heating of the massecuite to the saturation temperature to facilitate the purging at the low-grade centrifugals. In the mixers with rotating coils, where hot water is circulated, the temperature of the water should not exceed 5 F above the saturation temperature to avoid dissolution of crystals.

SUMMARY

When the exhaustion of final molasses in a boiling house is not satisfactory, that is under 50 points drop in purity from syrup to final molasses, is time to start looking into the two ratios mentioned at the beginning of this paper. The reducing sugars-ash ratio will show if a particular type of final molasses could have been exhausted further within practical limits.

In case of an affirmative answer and the exhaustion is not adequate, the impurity-water ratio will show a low figure, meaning poor pan work or an inadequate crystallizer performance.

To substantiate our findings two graphs have been drawn indicating the relationship between the apparent purity of our final molasses throughout two crops versus the reducing sugars-ash ratio and the impurity-water ratio.

As a relationship exists between the two variables of each graph, it is desirable to express it in a mathematical form by determining an equation connecting the variables. A recollection of data is shown in Tables 1, 2, 3, and 4 with the corresponding values of the variables under consideration.

Table 1. Reducing sugar-ash ratio. Method of least squares.

Apparent purity (Y)	Reducing sugars (%)	Sulph. ash (%)	Ratio		
			X	X ²	XY
31.80	14.43	12.66	1.14	1.30	36.25
31.48	16.22	13.40	1.21	1.46	38.09
32.09	14.93	13.45	1.11	1.23	35.59
31.88	15.39	13.79	1.12	1.25	35.71
33.25	13.13	13.43	.98	.96	32.59
33.62	13.05	14.34	.91	.83	30.59
33.69	12.66	13.80	.92	.85	30.99
33.78	14.29	14.43	.99	.98	33.44
35.29	11.03	13.85	.80	.64	28.23
35.74	12.00	14.38	.83	.69	29.66
35.05	12.30	14.60	.84	.71	29.44
35.88	12.52	14.43	.87	.76	31.22
35.70	12.10	14.30	.85	.72	30.34
34.72	13.07	13.88	.94	.88	32.64
33.70	12.70	13.85	.92	.85	31.00
34.13	15.10	14.01	1.08	1.17	36.86
33.30	13.10	13.50	.97	.94	32.30
35.18	12.57	13.43	.94	.88	33.07
34.90	11.76	12.66	.93	.86	32.46
35.90	12.50	14.40	.87	.76	31.23
37.68	10.99	14.43	.76	.58	28.64
37.55	10.68	14.60	.73	.53	27.41
37.16	10.51	14.73	.71	.50	26.38
36.93	9.97	13.80	.72	.52	26.59
$\Sigma Y=830.40$			$\Sigma X=22.14$	$\Sigma X^2=20.85$	$\Sigma XY=760.72$

Table 2. Reducing sugar-ash ratio. Calculation of standard deviation of Y.

Apparent purity (Y)	Curve purity (Y)	Difference (Y - Y)	Difference square (Y - Y) ²	Std. deviation
31.80	32.59	.81	.66	$sy = \sqrt{\frac{\Sigma(Y-\bar{Y})^2}{N}}$
31.48	31.86	.36	.13	
32.06	32.91	.85	.72	
31.88	32.80	.92	.85	
33.25	34.27	1.02	1.04	
33.62	35.00	1.38	1.90	
33.69	34.90	1.21	1.46	
33.78	34.17	.39	.15	
35.29	36.16	.87	.76	
35.74	35.84	.10	.01	
35.05	35.74	.69	.48	
35.88	35.42	.46	.21	
37.68	36.58	1.10	1.21	
37.55	36.89	.66	.44	
37.16	37.10	.06	.004	
36.93	36.99	.06	.004	
35.70	35.80	.10	.01	
34.72	34.68	.04	.002	
33.70	34.93	1.23	1.54	
34.13	33.22	.91	.83	
33.30	34.29	.99	.98	
35.18	34.73	.45	.20	
34.90	34.82	.08	.006	
35.90	35.44	.46	.21	
N=24		$\Sigma(Y-\bar{Y})^2=13.79$		$sy = \sqrt{\frac{.574}{24}} = .24$

Table 3. Impurity-water ratio by the method of least squares.

Apparent purity (Y)	Ratio		
	X	X ²	XY
32.06	3.71	13.76	118.94
32.08	3.68	13.54	118.05
32.69	3.74	13.99	122.26
33.25	3.62	13.10	120.36
33.97	3.49	12.18	118.55
33.87	3.50	12.25	118.54
33.95	3.58	12.82	121.54
34.41	3.34	11.16	114.93
34.55	3.21	10.30	110.90
34.90	3.46	11.97	120.75
35.18	3.37	11.36	118.56
35.55	3.07	9.42	109.14
35.88	3.07	9.42	110.15
35.85	3.56	12.67	126.63
35.67	3.36	11.29	119.85
37.68	3.05	9.30	114.92
37.20	2.97	8.82	110.48
37.55	2.97	8.82	111.52
$\Sigma Y=626.29$	$\Sigma X=60.75$	$\Sigma X^2=260.17$	$\Sigma XY=2106.07$

Table 4. Impurity-water ratio. Standard deviation of apparent purity.

Apparent purity (Y)	Curve purity ($\bar{Y}$)	Differences (Y - $\bar{Y}$)	Differences square (Y - $\bar{Y}$) ²	Std. deviation
32.06	32.55	.49	.24	$sy = \sqrt{\frac{\Sigma(Y-\bar{Y})^2}{N}}$
32.08	32.75	.67	.45	
32.69	32.35	.34	.12	
33.25	33.15	.10	.01	
33.97	34.03	.06	.004	
33.87	33.96	.09	.008	
33.95	33.42	.53	.28	
34.41	35.04	.63	.40	
34.55	35.91	1.36	1.85	
34.90	34.23	.67	.45	
35.18	34.84	.34	.12	
35.55	36.85	1.30	1.69	
35.88	36.85	.97	.94	
35.85	33.56	.29	.08	
35.67	34.90	.77	.59	
37.68	36.98	.70	.49	
37.20	37.52	.32	.10	
37.55	37.52	.03	.009	
N=18		$\Sigma (Y-\bar{Y})^2=7.81$	$sy = \sqrt{\frac{.43}{.21}}$	

On the scatter diagram, Fig. 1, the values found are plotted, considering the apparent purity as the dependent variable and the reducing sugars-ash ratio the independent variable. The scatter diagram in Fig. 2 shows the finding when the impurity-water ratio is considered the independent variable. An inverse correlation exists in both cases as the purity decreases whenever the ratio increases. To find the best fitting curve to connect the points plotted on a rectangular coordinate system, the method of least squares has been used, whose mathematical equation is written:

$$Y = a_0 + a_1 X$$

Where the constants a_0 and a_1 are determined from the formulas

$$a_0 = \frac{(\Sigma Y)(\Sigma X^2) - (\Sigma X)(\Sigma XY)}{N \Sigma X^2 - (\Sigma X)^2} \quad a_1 = \frac{N \Sigma XY - (\Sigma X)(\Sigma Y)}{N \Sigma X^2 - (\Sigma X)^2}$$

When comparing from the scatter diagram in Fig. 1 the actual values of the apparent purity with its curve value, a standard deviation of 0.24 is found, which shows how close the curve fits.

The standard deviation for the scatter diagram in Fig. 2 is 0.21, which also could be considered as a good fitting curve.

CONCLUSION

The performance of a boiling house could be analyzed by the following factors:

1. Final molasses exhaustibility is mostly determined by the reducing sugars-ash ratio.
2. A purity drop of 50 units from syrup to final molasses is feasible when the ratio of reducing sugars-ash is greater than 1.0.
3. Poor exhaustion, with a reducing sugars-ash ratio above 1.0, will indicate a low impurity-water ratio.
4. A low impurity-water ratio will generally mean poor pan performance or inadequate crystallizer technology.
5. The concentration of the low grade massecuite should be carried far enough to obtain an impurity-water ratio above 3.50.

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SUGAR EXHAUSTION BY MASSECUITE COOLING

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ABSTRACT

This paper is presented to emphasize the advantage of cooling off high grade massecuites. Examples and calculations of the higher sugar yield obtained are presented.

In regards to molasses desugarization by cooling, not much attention has generally been paid to the cooling of the so-called high grade massecuite.

Here in Florida, out of 8 sugar houses only 2, as far as we know, have the equipment and cool off the high grade massecuite.

The advantages of the cooling off of these massecuites are tremendous from several points of view, including:

- a) Sugar savings; since we are crystallizing sucrose by taking heat out of the massecuite instead of adding heat (always burning some sugar) as we do in the vacuum pan.
- b) Steam saving; same as for the previous reason.
- c) Capacity increase; since we are doing in the crystallizers what otherwise we would have to do in the vacuum pans. This increase in capacity also reflects in the centrifugal department since we are able to put in them massecuites of larger size crystals.

In Table 1 we show a comparison of the purity drop in the high grade massecuites in 3 different sugar houses.

Table 1. Drop in purity in 3 sugar houses.

Parameter	Sugar house		
	Case no. 1	Case no. 2	Case no. 3
1st. mass purity	82.14	83.38	81.35
1st. mol. purity	61.22	66.79	63.39
Drop in purity	20.92	16.59	17.96
2nd. mass purity	77.87	74.53	70.68
2nd. mol. purity	57.37	56.56	51.41
Drop in purity	20.50	17.97	19.27
Purity of sugar	99.18	98.41	98.67

Case no. 1 is with cooling of these massecuites, Cases no. 2 and 3 are without cooling.

In table 2 we can see the calculation of the sugar recovery from each massecuite in the above mentioned cases.

Table 2. Calculation of sugar recovery from the massecuites in Table 1.

Sugar house	Calculation of sugar recovery (%)			
<u>Case no. 1:</u>				
1st. mass:	$\frac{99.18}{82.14}$	$\frac{(82.14 - 61.22)}{(99.18 - 61.22)}$	x 100	= 66.54
2nd. mass:	$\frac{99.18}{77.87}$	$\frac{(77.87 - 57.37)}{(99.18 - 57.37)}$	x 100	= 62.45
<u>Case no. 2:</u>				
1st. mass	$\frac{98.41}{83.38}$	$\frac{(83.38 - 66.79)}{(98.41 - 66.79)}$	x 100	= 61.92
2nd. mass	$\frac{98.41}{74.53}$	$\frac{(74.53 - 56.56)}{(98.41 - 56.56)}$	x 100	= 56.68
<u>Case no. 3:</u>				
1st. mass	$\frac{98.67}{81.35}$	$\frac{(81.35 - 63.39)}{(98.67 - 63.39)}$	x 100	= 61.77
2nd. mass	98.67	$\frac{(70.68 - 51.41)}{(98.67 - 51.41)}$	x 100	= 56.92

We can easily see how in Case no. 1, notwithstanding the higher purity of the sugar being produced, the recovery obtained is much greater. The figures shown are actual figure averages of the 3 sugar factories. As has been seen, the benefit of the cooling off of the high grade massecuite is unquestionable.

One reason that has been raised against the fast cooling of massecuites, high grade as well as low grade, is the danger or risk of smearing the massecuite in the crystallizers. We can tell you out of a long experience that when you get a massecuite with false grain in the crystallizers, the reproduction was originated (for one reason or another) in the vacuum pans during the boiling.

Just let us think that we are not using ice water as a cooling element, and besides that, the meta-stable zone of crystallization is sufficiently ample to permit us to play with supersaturation and velocity of crystallization.

SYMPOSIUM: LIQUID EFFLUENTS DISPOSAL
PROBLEMS IN THE CANE SUGAR INDUSTRY

(No paper was available on this symposium for the Proceedings).

FIELD LOSSES AND TRASH CONTENT OF HAND-CUT AND
MECHANICALLY-HARVESTED SUGARCANE IN FLORIDA

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ABSTRACT

This paper reports the results of field studies to evaluate the trash content, field losses and length of cut of different mechanical-harvesting systems and compares them with hand-cut, mechanically-loaded systems. Samples were taken at 2-week intervals while the systems were operating between Nov. 7, 1972 and May 22, 1973. Samples from unburned cane were taken but operation was usually under simulated production conditions. The two hand-cut systems averaged 5.5% total trash for the season and contained almost equal amounts of green and dry material. The mechanical-harvesting systems averaged 8.3% total trash but contained 6.4 percentage points of green trash and 1.9 points of dry trash. Field losses averaged 2.84 tons per acre or 5.3% of total yield for the hand-cut systems and averaged 3.75 tons per acre or about 8.6% of the total yield for the harvesters. The length of cane pieces from the continuous loader averaged 16.9 in., while lengths for the mechanical harvesters ranged from 10 to 15 in. and averaged 12.4 in. The increase in amount of green trash in the mechanically-harvested sugarcane was the most striking difference between the systems. This increased trash indicates the difficulty encountered in mechanically topping recumbent sugarcane uniformly with the harvesters.

INTRODUCTION

Almost 1.5 million tons of sugarcane, or about 15% of the Florida crop, was harvested mechanically during the 1972-73 season. One mill cut all of its 1972 crop mechanically. An additional investment in mechanical-harvesting equipment will be made for the 1973 crop. A USDA study was undertaken in 1972 to evaluate the economics of mechanically harvesting sugarcane in Florida. This paper reports results of the field studies conducted during the 1972-73 harvest season to evaluate field losses, trash content, and the length of cut resulting from the use of different mechanical-harvesting systems in the Florida sugarcane area.

Trash in cane increases both the bulk and the weight that is hauled to the mill and processed. In addition, the composition of the trash (amount of green and dry matter) may have an adverse effect on the quality of juices extracted and the recovery of raw sugar. Field losses are important because they may be an added cost to the mechanical-harvesting system. The length of cane pieces from the different systems is important because it has an effect on the compaction of cane in the hauling containers and on pneumatic trash removal on the conveyers. The shorter lengths may affect the rate of deterioration in cane which is stored before being milled.

MATERIALS AND METHODS

Field samples were taken at 2-week intervals, from November 7, 1972, to May 22, 1973, from two hand-cutting systems and 4 mechanical-harvesting systems operating in burned cane. Two 40-lb trash samples were caught from the conveyors of the continuous loaders and mechanical harvesters. These samples were weighed, cleaned in accordance with standard procedures, and reweighed. Trash was separated into green and dry material, and each type was weighed separately.

Field loss studies were completed at the same time that trash samples were collected. An area behind the harvester or loader was marked, and all the millable sugarcane remaining in the area was collected and weighed. This field loss included cane which was cut too high at the base, tops which were cut too long, and cane that was missed or dropped by the cutting and loading machinery. The field loss samples were taken before workers passed over the area to recover some of the cane lost by the machinery. A 4-row width behind the continuous loader, a 2-row width behind the 2-row harvester, and a 1-row section behind the 1-row harvester were measured for the field loss tests.

The length of cane pieces was measured during 2 of the test periods and periodically thereafter when it was felt that there was some change in a system which might affect the length of cut.

Samples of unburned cane were taken from each harvesting system, but the results should be used with caution since it was difficult to simulate production conditions. The harvesters were operated only briefly,

or the operation was simulated. Therefore, the samples and feeding rates were much different from those of actual operation. Field loss studies were not made in the unburned tests.

RESULTS

The two hand-cut systems had an average of 5.5% total trash for the 1972 crop (Table 1). Dry material accounted for 2.8% of this trash, and green material accounted for 2.7%. The mechanical-harvesting systems had an average of 8.3% total trash for the season. Of this, 1.9% was dry trash and 6.4% was green trash.

Table 1. Trash content, field loss, and length of cut for mechanically-harvested and hand-cut burned sugarcane in Florida, 1972 crop.

Sample no.	Trash content (%) ^{1/}			Field loss Tons/acre	% ^{2/}	Average length of cut (in.)
	Dry	Green	Total			
Hand-cut						
1	2.5 (50)	2.5 (50)	5.0	2.83	5.1	17.2
2	3.1 (52)	2.9 (48)	6.0	2.86	5.5	16.6
Av.	2.8 (51)	2.7 (49)	5.5	2.84	5.3	16.9
Mechanically-harvested						
1	2.1 (19)	8.9 (81)	11.0	3.43	6.8	14.8
2	2.0 (22)	7.1 (78)	9.1	4.44	11.9	11.0
3	2.1 (31)	4.7 (69)	6.8	3.69	7.7	14.0
4	1.3 (20)	5.1 (80)	6.4	3.66	7.9	9.8
Av.	1.9 (23)	6.4 (77)	8.3	3.75	8.6	12.4

^{1/} Numbers in parentheses are the percentages of total trash.

^{2/} Percentage of total yield (cane harvested plus field loss).

An important difference between the trash in samples from hand-cut systems and the trash in cane from mechanical-harvesting systems is the proportion of dry and green material. The hand-cut cane had about equal amounts of dry and green material in the trash. The dry material averaged 51%, by weight, and the green material, 49%. Trash from the mechanically-harvested cane generally had about 3 times as much green material as dry material. The dry material for the 4 mechanical-harvesting systems averaged 23%, by weight, and the green material, 77%.

Field losses per acre were calculated from the amounts of cane recovered from the test areas (Table 1). The field loss percentages in Table 1 are percentages of total yield (cane harvested plus field loss). Field losses averaged 3.3 percentage points higher for the mechanical-harvesting systems than for the hand-cutting systems. Losses for the 2 hand-cutting systems averaged 2.84 tons per acre, or an average loss of 5.3% of the total yield. The average field loss for the mechanical-harvesting systems was 3.75 tons per acre, or about 8.6% of total yield.

The length of cane pieces from the continuous loader averaged 16.9 in.; whereas, the lengths from the mechanical cutters ranged from 10 to 15 in. and averaged 12.4 in.

The unburned samples from the mechanical-harvesting systems averaged 10.4% total trash (Table 2). Of this amount, 3.1% was dry material, and 7.3% was green material. The unburned hand-cut samples averaged 12.7% total trash, of which 10.1% was dry material and 2.6% was green material. All unburned samples were from simulated conditions and are not necessarily representative of a field operation.

Table 2. Trash content for mechanically-harvested and hand-cut green sugarcane in Florida, 1972 crop.

Sample no.	Trash content (%) ^{1/}		Total
	Dry	Green	
Hand-cut			
1	15.0 (86)	2.4 (14)	17.4
2	5.2 (65)	2.8 (35)	8.0
Av.	10.9 (80)	2.6 (20)	12.7
Mechanically-harvested			
1	2.0 (19)	8.3 (81)	10.3
2	4.7 (34)	9.0 (66)	13.7
3	3.3 (35)	6.2 (65)	9.5
4	2.4 (30)	5.6 (70)	8.0
Av.	3.1 (30)	7.3 (70)	10.4

^{1/} Numbers in parentheses are the percentages of total trash.

DISCUSSION

The most striking difference in the amount of trash between the hand-cut and mechanical-harvesting systems was the greater amount of green trash in the mechanically-harvested sugarcane. Although there were differences among the mechanical-harvesting systems, they had a consistently higher proportion of green material in the cane trash than did the hand-cut system. This greater amount of green trash resulting from the mechanical system reflects the difficulties encountered in topping recumbent cane uniformly with mechanical harvesters. The additional green trash consisted largely of immature stem and leafy top. The pneumatic extractors on the mechanical harvesters effectively removed dry material and loose green leaves but could not separate the heavier green material from the cane stalks.

Green trash such as immature stems, green leaves, and sucker growth contain relatively low percentages of sucrose in the normal juices (NJS) and a relatively high proportion of nonsucrose solubles (1,2). Increases in green trash reduce NJS and normal juice purity. Hence, mechanically-harvested cane can be expected to yield lower NJS than hand-cut cane, which will result in a lower sugarcane quality having poorer milling qualities.

The amount of dry trash in the hand-cut green cane was high because no attempt was made to remove it. The hand-cut was loaded with the continuous loader. The mechanically-harvested unburned cane had a relatively low dry-trash content, because the pneumatic cleaners removed a substantial amount of the dry leaves on the small samples used in this study.

Although the field loss from mechanically-harvested sugarcane averaged about 3.75 tons per acre, this loss was only about 1 ton per acre more than the field loss from the hand-cut system. The difference in field loss between mechanical harvesting and hand cutting is important primarily in evaluating the costs between the 2 systems. An additional field loss of 1 ton per acre is not likely to be a major factor for mechanical harvesting.

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COSTS FOR MECHANICALLY HARVESTING SUGARCANE IN FLORIDA

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ABSTRACT

Costs for harvesting sugarcane in Florida are compared for hand-cutting and mechanical-harvesting systems during the 1972-73 season. Machinery ownership and operation costs were \$1.34 per gross ton for mechanical harvesting and \$0.64 for the hand-cut-continuous-loader system. Labor costs per gross ton were \$1.41 for the mechanical system and \$2.85 for the hand-cutting system. Other costs for the mechanical-harvesting system--including additional field loss, reduced sugarcane quality factor, and reduced government sugar payment--were \$0.67 per gross ton. Total cost per gross ton was \$3.42 for machine harvesting and \$3.49 for hand-cutting. The total cost per net ton of sugarcane was \$3.83 for mechanical harvesting and \$3.69 for hand-cutting-continuous-loader. Mechanical harvesting costs are expected to be lower in the future when equipment is operated to obtain higher annual outputs.

INTRODUCTION

Sugarcane harvesting costs can be elusive items to estimate, especially when the estimates are for the purpose of comparing the hand-cutting of sugarcane with mechanical-harvesting methods. For example, one method may have a lower fixed cost, another a lower labor cost, a third a lower field loss, and a fourth a lower trash content in the harvested cane. These differences are converted to dollar costs in this report, and comparisons are made between systems.

There are two objectives for this paper. The first is to present one method of evaluating cost differences between the hand-cutting system and the several mechanical systems for harvesting sugarcane. The second objective is to present estimates of cost differences between the hand-cutting and mechanical harvesting of sugarcane in Florida for the 1972 crop.

PROCEDURE

Machinery ownership, operating costs, and labor are the most obvious cost items and are the ones most often referred to when the costs of various harvesting systems are compared (3, 9). These cost items include those such as fuel, oil, repairs, wages, interest, taxes, insurance, and depreciation.

In addition to those mentioned, there are other costs which contribute to the profitability of one system over another. Three of these additional costs will be discussed briefly. They are referred to herein as additional field loss, reduced standard sugarcane quality factor, and reduced government sugar payment. The costs discussed in this report are ones that would normally be paid by an independent grower. They include costs for cutting, loading, and in-field hauling. Mechanical-harvesting may also have an effect on the sugar mill's costs. These costs, which are not covered in this report, are those such as additional hauling costs, additional mill operating costs; and costs from reduced sugar recovery. Another cost not covered in this report is the cost that could result from the potentially greater loss from freeze damage when cane is harvested mechanically rather than by hand-cutting, because of the inability of mechanical-harvesters to separate deteriorated cane from good cane.

The additional field loss is a charge made against mechanical harvesting for cane losses that exceed the amount that would be lost if the hand-cutting system were used. It is a charge for sugarcane not recovered. The additional field loss is derived by estimating the reduced revenue due to the additional sugarcane loss caused by mechanical-harvesting minus the cost that would be incurred in hand cutting this additional sugarcane and loading it with the continuous loader. The additional field loss could be an additional revenue for mechanically harvested cane if field losses were lower for mechanical harvesting than for hand cutting. There are two sources of additional field loss. The first source is sugarcane missed by the harvesters and left in the field. Additional field losses from this first source for mechanical-harvesting systems in Florida for the 1972 sugarcane crop averaged about 1 ton per acre more than for the hand cutting system (4). The second source of field loss is reduced average yield from ratoon crops due to greater root damage as a result of mechanical harvesting. Opinions differ about the effects of mechanical harvesting on ratoon crops, but industry personnel who were involved in much of the mechanical harvesting of the 1972 sugarcane crop report that regrowth in their mechanically cut fields compared favorably with regrowth in their hand cut fields (3). In this study, yields from ratoon crops were assumed to be the same for the mechanically-harvested and the hand-cut sugarcane. If further experience indicates that losses for this second source are higher for mechanical harvesting, the effects on cost can be estimated by increasing the additional field loss accordingly.

The reduced standard sugarcane quality factor is a charge made against mechanical harvesting for the reduced normal juice sucrose (NJS), which results in a lower standard sugarcane quality factor when cane is harvested mechanically. Payment for sugarcane is made on the basis of standard tons of sugarcane, which in turn are based on a standard sugarcane quality factor. The standard sugarcane quality factor is based on the NJS. Therefore, a reduced standard sugarcane quality factor results in lower payments for each net ton of sugarcane harvested.

The amount of trash in harvested sugarcane affects the value of the sugarcane. Separating sugarcane trash such as tops, suckers, and other undesirable material from the sugarcane stalks is more difficult when harvesting mechanically than when hand cutting. Hence, mechanically-harvested sugarcane tends to have a higher trash content than hand-cut sugarcane (4). The amount and kind of trash in sugarcane has an effect on the NJS (2, 6). Trash such as immature stalks, green leaves, and sucker growth contain relatively low percentages of sucrose and relatively high proportions of nonsucrose solubles. Increases in trash due to mechanical harvesting tend to reduce the NJS and purity of normal juice. Milling tests conducted at the USDA Sugarcane Field Station, Canal Point, Florida, during the 1972-73 season showed an average decrease of 0.42% in the NJS of mechanically-harvested cane in comparison with hand-cut cane. This reduction was the equivalent of a 0.042 decrease in the standard sugarcane quality factor (8).

Reduced government sugar payment is a charge made against mechanical harvesting for a lowering of estimated commercially recoverable sugar (CRS). There are two sources of this loss. The first is a lower NJS in sugarcane that has been mechanically harvested. Government sugar payment is based on estimated commercially recoverable sugar. The schedule for estimating CRS per ton of sugarcane is related to the NJS of the cane (7). A decrease in the NJS due to increased trash in mechanically harvested sugarcane results in a lower estimate of CRS, hence a reduced government sugar payment per net ton of cane.

The second source of reduced government sugar payment is the sugar lost in the additional field loss. The higher field losses that occur when cane is harvested mechanically result in the delivery of fewer net tons to the mill and consequent loss of government sugar payments on the sugar that was lost in this additional field loss.

HARVESTING COSTS, 1972 CROP

Cost estimates were selected to be representative of hand cutting and mechanical harvesting for the Florida industry. Since some mills have different systems for loading and transporting cane, the costs may not be applicable for a particular mill. The mechanical-harvesting cost estimates for the 1972 crop are weighted averages of the costs of 3 mechanical-harvesting systems. The weighting was based on the amount of cane harvested by each system. A total of 1,343,826 tons, which represents 90% of all mechanically harvested sugarcane in Florida, was harvested by these 3 systems during the 1972-73 season.

Estimates of machinery ownership and operating costs and of labor costs were derived by the budgeting method. When available, actual cost data were used in the budgets. The added costs caused by the increased field loss, reduced sugarcane quality factor, and reduced government sugar payment were based on estimates of the effects of mechanical harvesting on NJS and on field losses. These effects were converted to estimates of the added costs mentioned above on the basis of ASCS standards for fair and reasonable payment for sugarcane and on relationships between NJS and trash contents as determined from USDA studies (2, 6).

The estimated average annual machinery ownership and operating cost for harvesting sugarcane in Florida for the 1972 crop was \$1.34 per gross ton for mechanical harvesting and \$0.64 for hand cutting and then loading with the continuous loader (Tables 1 and 2). The major cost items for all systems were depreciation and repairs and maintenance. The fuel, oil, grease cost and interest cost were other important cost items.

Table 1. Estimated average annual machinery ownership and operating costs for mechanically-harvesting sugarcane in Florida, 1972-73 season.

Item	Cutters	Field towing units	Field carts	Ramp, dumper, conveyor	Pickup truck, busses	Main- tenance equipment ^{1/}	Total
----- (dollars per 100,000 gross tons) -----							
Initial investment	177,274	128,283	47,593	10,700	8,504	2,669	375,023
Costs							
Annual depreciation ^{2/}	16,490	14,159	2,880	822	1,793	351	36,495
Repair and maintenance ^{3/}	28,086	21,340	8,407	298	655	596	59,382
Taxes, licenses, insurance ^{4/}	989	713	284	93	244	45	2,368
Fuel, oil, grease ^{5/}	6,971	10,989	17	320	864	160	19,321
Interest ^{6/}	7,800	5,644	2,094	471	359	117	16,485
Total annual cost ^{7/}	60,336	52,845	13,682	2,004	3,915	1,269	134,051
Cost per gross ton	0.60	0.53	0.14	.02	.04	.01	1.34

- 1/ Includes equipment such as fuel trucks, small tractors, air compressor, and grease filter.
2/ Estimated at .9 x initial investment divided by service life. Length of service life was based on estimates by industry personnel who were working with the different systems.
3/ Includes costs for field repairs and end of season overhaul. Taxes and insurance for some mills were reported with repair and maintenance costs.
4/ Taxes and insurance were estimated at .035 times the average value of investment unless reported differently by the mills.
5/ Based on fuel, oil, and grease requirements for similar equipment given in the 1969 Agricultural Engineers Yearbook (1) unless reported differently by the mills.
6/ Estimated at 8% of the average value of investment.
7/ Exclusive of labor costs.

Table 2. Estimated annual machinery ownership and operating costs for harvesting sugarcane in Florida with the hand-cut, continuous-loader system, 1972-73 season.

Item	Con- tinuous loader	Field towing units	Field carts	Ramp, dumper, conveyor	Pickup trucks	Main- tenance equip- ment ^{1/}	Labor support equip- ment ^{2/}	Total
----- (dollars per 100,000 gross tons) -----								
Initial investment	36,362	90,502	41,372	31,837	3,232	4,956	10,235	218,496
Costs								
Annual depreciation ^{3/}	3,273	9,818	2,482	3,149	727	517	970	20,936
Repair and maintenance ^{4/}	3,636	10,909	5,172	2,219	485	404	404	23,229
Taxes, licenses, insurance ^{5/}	700	1,742	796	613	100	114	254	4,319
Fuel, oil, grease ^{6/}	1,108	3,709	---	198	431	240	323	6,009
Interest ^{7/}	1,600	3,982	1,820	1,401	142	218	450	9,613
Total annual cost ^{8/}	10,317	30,160	10,270	7,580	1,885	1,493	2,401	64,106
Cost per gross ton	0.10	0.30	0.10	0.08	0.02	0.01	0.02	0.64

- 1/ Includes fuel trucks, grease trailer, field water cart, and a small tractor.
2/ Includes food truck, large van, small van, and wagon for drinking water.
3/ Estimated at .9 x initial investment divided by service life.
4/ Includes costs for field repairs and end of season overhaul.
5/ Taxes and insurance were estimated at .035 times the average value of investment.
6/ Based on fuel, oil, and grease requirements for similar equipment given in the 1969 Agricultural Engineers Annual Yearbook (1).
7/ Estimated at 8% of the average value of investment.
8/ Exclusive of labor cost.

The estimated annual costs per gross ton are summarized in Table 3. The total cost per gross ton was \$3.42 for mechanical harvesting and \$3.49 for hand cutting and then loading with the continuous loader.

Table 3. Summary of estimated annual costs per gross ton for the mechanical harvesting and the hand cutting of sugarcane in Florida during the 1972-73 season.

Item	Mechanical harvesting	Hand cutting
<u>Cost per gross ton</u>		
Machinery ownership and operation	\$1.34	\$.64
Labor costs ^{1/}	\$1.41	\$2.85
Reduced standard sugarcane quality factor	\$.39	--
Additional field loss	\$.24	--
Reduced government sugar payment	\$.04	--
Total	\$3.42	\$3.49
Net cane factor ^{2/}	89.3%	97.7%
Cost per net ton ^{3/}	\$3.83	\$3.69

1/ Included costs for equipment operators, cane cutter, scrappers, supervisors, dump operators, ticket writers, and usually a utility man. Labor costs were based on wages earned plus 25% for overhead unless reported differently by the mills.

2/ Net cane factor = 100 - (% trash in cane). Data reported to ASCS, by mills showed that mechanically-harvested sugarcane averaged 10.7% trash and hand-cut sugarcane averaged 5.3% trash in Florida for the 1972 crop.

3/ Cost per net ton = cost per gross ton divided by net cane factor.

Since the average trash percentage was higher for mechanically-harvested cane than for hand-cut cane, costs were converted to a net ton basis by dividing the cost per gross ton by the net cane factor. The total cost per net ton was \$3.83 for mechanically-harvested cane and \$3.69 for hand-cut cane.

DISCUSSION

The mechanically-harvesting costs for the 1972 sugarcane crop may be higher than would be representative of future years. Most mechanical-harvesting operations were partially experimental during the 1972 crop. Some of the costs could have been treated as research and development or training costs. The mechanical harvesters generally were not operated at capacity for one reason or another. Mechanical-harvesting costs will probably decline for the 1973 crop when the equipment is operated to obtain higher daily outputs. In contrast, the labor-cost component of the hand cutting system will probably continue to increase. Labor cost is a large part of the total hand-cutting cost and, in recent years, generally has increased faster than other costs.

Although the costs of additional field loss, reduced standard sugarcane quality factor, and reduced government sugar payment total \$0.67 per gross ton, they account for a relatively small percentage of the total cost of mechanical harvesting. They will not likely be prohibitive for mechanical harvesting.

As mentioned earlier, additional milling costs caused by mechanical harvesting were not included in this paper. Studies conducted at the Audubon Sugar Factory at Baton Rouge, Louisiana, indicated that a 1% increase in cane trash reduced grinding rates by 5.85%, increased power requirements, and reduced sucrose extraction (5). Florida mills are larger and may be able to handle the additional trash in sugarcane better than the experimental Audubon mill. However, Florida mills will probably have additional costs when they process mechanically-harvested sugarcane. These costs must be added to mechanical-harvesting costs for an accurate comparison between the costs of harvesting and hand-cutting.

ACKNOWLEDGEMENT

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MAINTAINING MAXIMUM YIELDS WITH SKIP PLANTING

J. W. Beardsley

(This paper was not available for printing in the Proceedings. An abstract is presented in an earlier section of these Proceedings).

PANEL DISCUSSION: LABOR - NEW REGULATIONS

(No paper was available on this discussion for the Proceedings).

PAPERS PRESENTED AT MEETING OF LOUISIANA DIVISION

February 1, 1973

TRASH SAMPLING STUDIES AT LOUISIANA SUGARCANE MILLS

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I was employed as a consultant for the Louisiana Farm Bureau Federation from 1970 to 1973 to survey sugarcane mills in Louisiana during the grinding season to determine if their sampling procedures for sucrose % (cane) and trash % (cane) were being done properly. Additionally, studies applicable to trash percentage determinations were also conducted.

During the 1972-73 grinding season there were indications that trash percentages being obtained at mills were higher than what had normally been experienced. In order to compare trash percentages during the 1972-73 grinding season with that of previous years, a questionnaire was sent to all sugarcane mills in Louisiana requesting them to submit their average trash % for the period from 1947 to 1972. Eighteen mills responded to the questionnaire and the results are presented in Table 1.

The trash % for the 1972-73 season was an average of the first 40 crop days while the averages for the 1947-1971 seasons were based on the entire season.

Trash % varied among mills each year but these differences were not considered to be large. However, there was considerable variation in trash % among years when the means of all 18 mills were compared. The trash % for the 1971 and 1972 seasons, 12.5 and 13.1, respectively, were the highest of all seasons surveyed.

In my opinion, factors partially responsible for the higher trash % for the 1971 and 1972 grinding seasons were as follows: high rainfall during the harvest, use of mechanical grabs at mills to obtain trash samples, changes in harvesting operations such as the use of push pilers, the placement of 6 rows on a heap, and varietal differences in trash content.

Table 1. Trash % for Louisiana Sugarcane Mills from 1947-1972.

	'72	'71	'70	'69	'68	'67	'66	'65	'64	'63	'62	'61	'60	'59	'58	'57	'56	'55	'54	'53	'52	'51	'50	'49	'48	'47	Mean
	18.3	16.9	11.9	11.9	13.5	6.1	4.7	8.1	4.6	4.7	8.6	7.9	9.0	10.0	9.7	7.7	5.0										8.8
ose	13.1	14.5	9.9	7.2	8.0	7.7	6.1	9.7	7.9	6.7	7.2	7.8	8.0	8.9	7.9	9.4	7.3	5.2	4.7	4.7	4.1	7.0					7.6
bridge	12.7	11.5	6.7	7.3	6.7	6.7	3.3	5.4	4.5	3.9	6.3	6.2	5.6	3.8	3.7	6.0	4.2	2.6	3.3	2.7	1.3	2.4	2.4	2.5	3.5		4.7
	10.4	14.1	9.2	7.6	6.7	6.2	3.9	6.0	4.0																		7.2
	12.0	10.7	9.2	5.9	6.7	5.7	4.7	8.9																			7.4
	12.2	9.9	7.2	6.8	6.9	4.7	7.1	7.3	5.4	4.7	8.0	7.9	8.6	6.0	5.8	7.4	5.3	4.7	5.7	4.7			2.5	2.2	2.7	2.0	5.8
se	12.2	12.4	6.7	6.5	9.7	8.3	6.5	6.2	5.8	5.5	7.0	7.2	8.5														7.5
	10.1	11.5	6.7	7.3	6.7	6.7	3.3	5.4	4.5	3.9	6.3	6.2	5.6	3.8	3.7	6.0	4.2	2.6	3.3	2.7	1.3	2.4	2.4	2.5	3.5		4.7
st John	11.5	12.4	7.5	7.8	8.1	7.2	5.9	7.2	4.9	4.7	9.5	8.0	9.1	6.2	7.1	7.5	4.6	2.6									7.1
	14.6	12.2	9.0	9.4	8.4	8.0	5.5	6.5	4.9	5.5	8.9	9.3	10.4	6.0	8.2	11.1	8.9	7.8	10.2	8.8	5.5	5.8	5.4	5.0	7.7		7.9
ld	12.2	11.9	9.0	8.8	8.3	7.1	7.0	8.7	8.0	6.3	14.0	7.5	9.2	6.4	6.9	7.5	5.5	5.0	4.9			3.0		5.2			7.1
ist)	11.9	10.2	5.9	5.3	6.6	6.1	4.6	6.1	4.5	4.2	7.9	7.0	7.6	5.5	6.3	7.7	5.9	4.7	5.2	3.7	2.4	4.0	3.6				5.7
ist (nne)	13.4	10.9	7.7	5.9	6.8	6.9	5.0	7.7	7.5	6.8	7.7	7.2	8.0	6.6	7.3	7.0	6.1	5.7	6.2	5.4	3.7	6.7	6.5	6.4	2.5	4.4	6.5
m (ux)	18.2	16.8	8.9	7.5	9.2	7.9	6.1	8.9	7.0	4.9	7.1	7.4	7.9	8.0	7.0	7.6	6.6	5.2	5.6	5.1	5.1						7.5
	12.3	11.1	6.6	6.3	6.7	5.2	4.3	6.1	5.1	4.1	7.0	6.5	7.7	5.2	4.9	6.4	4.2	3.0	3.7								5.8
	13.2	12.0	8.9	8.8	11.1	9.4	6.8	7.2	5.2	4.6	6.0	5.3	5.7	6.1	4.8	6.0	4.4	3.5	4.5	5.0	4.5	6.1	7.7	6.8	3.1	3.4	6.3
	14.1	10.9	6.1	6.0	7.3	6.2	4.6	6.0	5.5	4.4	12.5	7.2	8.4	5.3	5.7	6.8	4.4	5.6	6.4	5.3	3.6	3.4	4.2	3.2			6.0
d	14.4	14.3	8.7	6.9	7.7	6.4	5.5	11.4	7.9	6.9	9.4	8.4	7.8	8.5	7.7	8.3	6.6	4.0	3.8	4.6	3.1	5.2	5.7	4.5			7.1
	13.1	12.5	8.2	7.4	8.2	6.8	5.3	7.4	5.7	5.1	8.5	7.3	8.3	6.7	6.7	7.4	5.6	4.7	5.4	5.0	3.7	4.8	4.8	4.5	3.9	3.3	

*Trash % is the average of approximately the first 40 crop days.

Since amount of rainfall affects trash %, data were obtained to determine the relationship between trash % and the amount of precipitation occurring during the grinding season. The results of the study are presented in a scatter diagram shown in Fig. 1.

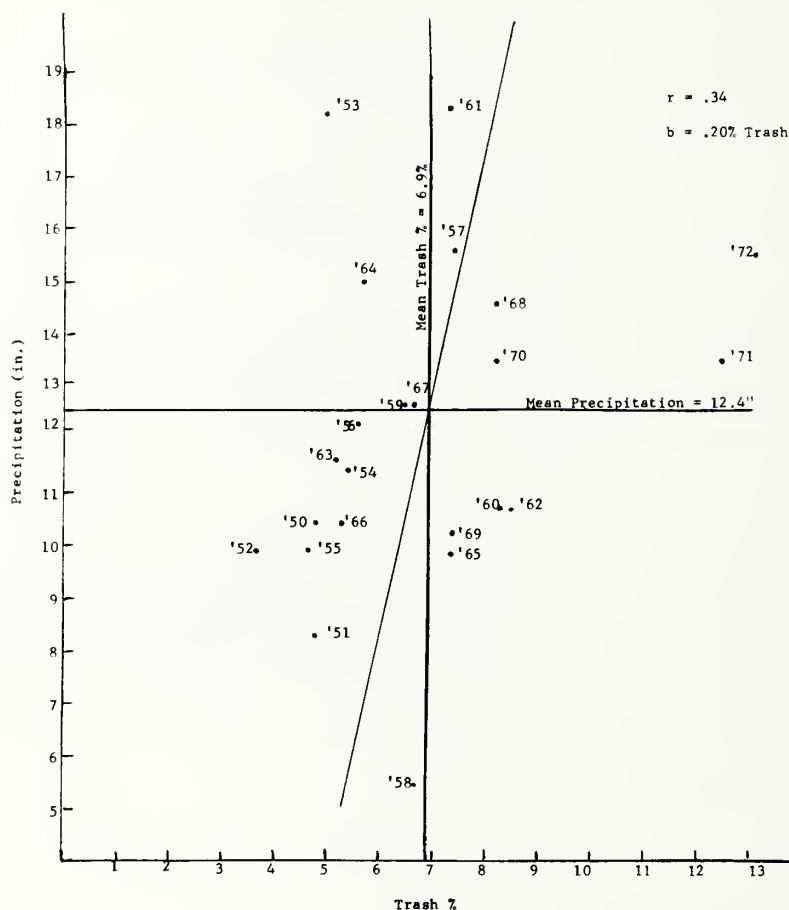


Fig. 1 Association between % trash and precipitation during the grinding seasons of 1950-1972.

The trash % is the average of the 18 mills listed in Table 1 for each year from 1950-1972. Rainfall data were obtained from U. S. Weather Bureau statistics, and rainfall was expressed as the average number of inches recorded at weather stations located in the sugarcane belt for a period from October to December, inclusive, for each year (2).

A correlation coefficient of .34 and a regression coefficient of .20% trash were obtained between trash % and rainfall. Although both values were nonsignificant, each was positive and suggests a moderate association. This indicated that as rainfall increased there was a tendency for trash % being obtained at mills to also increase. However, the association was not high, indicating other factors also affected trash %.

Varietal differences is another factor that could contribute to higher trash %. Data on trash % for a period from 1961 to 1972 were obtained from outfield variety tests for several varieties in plant cane and stubble crops and trash % was determined on hand cleaned 200 lb samples (1). The results are presented in Table 2.

Table 2. Percent trash for several varieties in outfield experiments in plant cane and stubble crops.
(Data from H. P. Fanguy and M. Giamalva.)

Variety	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	Average
Plant Cane													
CP 48-103	8	5	10	13	11	7	--	15	16	15	15	11	11.5
CP 52-68	7	11	7	5	8	7	10	9	11	10	14	13	9.3
CP 44-101	7	7	13	14	16	15	11	--	--	--	--	--	11.9
NCo 310	10	10	10	11	16	--	--	--	11	11	17	17	12.6
CP 61-37	--	--	--	--	11	8	11	14	9	12	13	16	11.7
L 60-25	--	--	--	7	8	8	11	20	9	15	15	18	12.3
CP 55-30	5	8	9	5	10	12	7	8	7	--	--	--	7.9
Average	7.4	8.2	9.8	9.2	11.4	9.5	10.0	13.2	10.5	12.6	14.8	15.0	11.0
First Stubble													
CP 48-103	11	11	9	8	8	12	13	--	17	15	16	13	12.1
CP 52-68	10	10	6	7	7	9	6	17	8	11	11	13	9.6
CP 44-101	10	17	7	10	10	12	15	--	--	--	--	--	11.6
NCo 310	13	17	13	12	11	11	--	--	--	10	18	13	13.1
CP 61-37	--	--	--	--	--	7	14	16	20	17	11	9	13.4
L 60-25	--	--	--	--	10	11	12	17	14	14	13	15	13.2
CP 55-30	8	8	9	7	12	10	10	12	13	13	--	--	10.2
Average	10.4	12.6	8.8	8.8	9.7	10.3	11.7	15.5	14.4	13.3	13.8	12.6	11.9
Second Stubble													
CP 48-103	--	17	10	9	10	14	18	20	--	18	13	20	14.9
CP 52-68	--	11	8	9	9	11	14	14	19	13	15	10	12.1
CP 44-101	--	14	12	11	9	14	17	--	16	--	--	--	13.3
NCo 310	--	17	11	14	19	--	15	--	--	--	--	14	15.6
CP 61-37	--	--	--	--	--	--	--	16	17	16	18	11	15.6
L 60-25	--	--	--	--	--	17	12	20	22	17	22	18	18.3
CP 55-30	--	11	10	7	9	11	14	19	14	17	10	--	12.2
Average	--	14.0	10.2	10.2	11.2	13.4	15.0	17.8	17.6	16.2	15.6	14.6	14.6

There was considerable interaction between varieties, years, and crops. Therefore, one must be careful in interpretation of the data. However, the data indicated that the trash % in stubble crops was generally higher than in plant cane, although the differences might not be significant. For example, the average trash % for all varieties as an average of all years was 11.0%, 11.9% and 14.6% for plant cane, first stubble and second stubble, respectively.

The data also indicated that there were varietal differences in trash %. For example, L 60-25, CP 61-37 and NCo 310 were generally higher in trash % than CP 55-30 and CP 52-68.

Regulations specified by the USDA require that the gross weight of trash samples must be a minimum of 50 lb and should be representative in nature (1). Because of the variability of trash % often occurring in a load of cane, there is considerable question whether this sample size is adequate to give a reliable indication of trash %. Therefore, 2 studies were conducted in 1972 to measure the variability of trash % and also to determine the relationship between size of trash sample and trash %.

In each study a tractor load of burned cane weighing approximately 4 tons was dumped on a carrier table at a sugarcane mill. Then samples of various sizes were taken at random utilizing a mechanical grab. Each sample was weighed, detashed, and the clean cane weight determined. Finally, data obtained were used to calculate trash % for each sample. Results from the 2 studies are shown in scatter diagrams in Fig. 2 and 3.

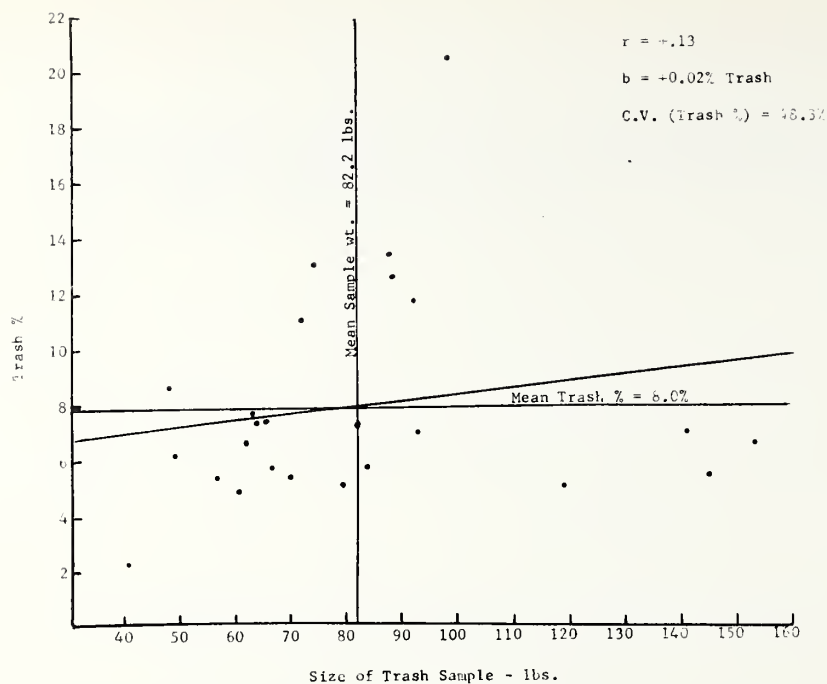


Fig. 2. Association between size of trash sample and % trash.

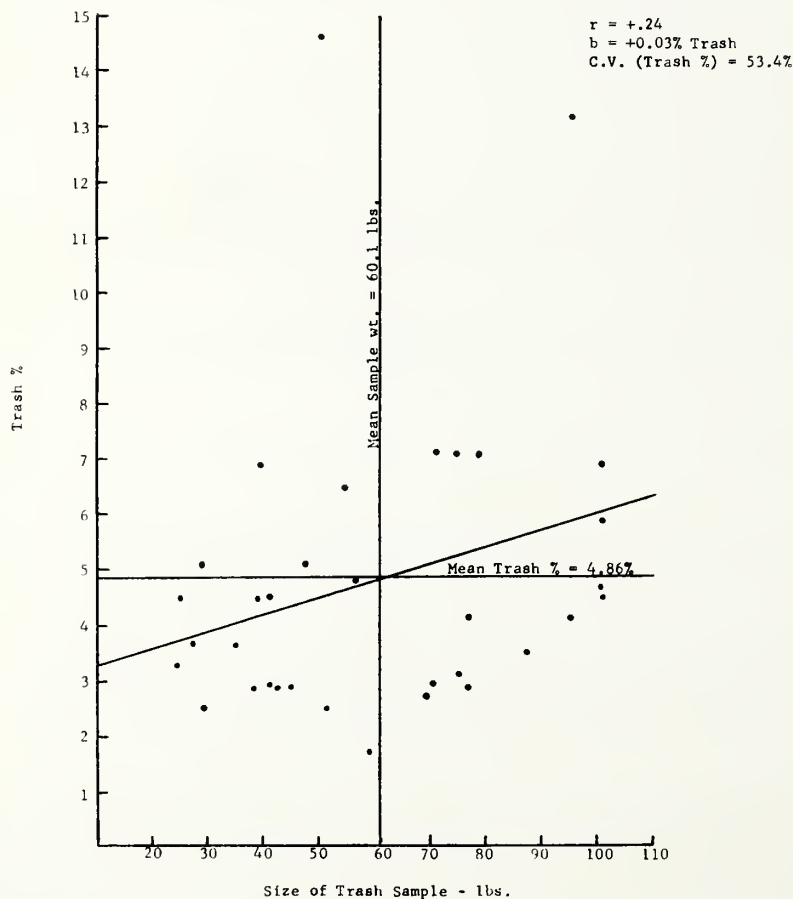


Fig. 3. Association between size of trash sample and % trash.

Twenty-five samples were taken in the study presented in Fig. 2. The range in size of the 25 samples was from 41 to 153.0 lb, with a mean weight of 82.2 lb. The range in trash % of the samples was from 2.44 to 20.41%, with an average of 8.00%. The coefficient of variation for trash % was 48.3%, indicating a high amount of variability. A correlation coefficient of .13 and a regression coefficient of .02% trash were obtained. Although both were positive, each was nonsignificant and low in magnitude.

Thirty-five samples were obtained in the data shown in Fig. 3. The sample sizes ranged from 22.5 to 101.4 lb, with a mean weight of 60.1 lb. The range of the samples for trash %, as measured by the coefficient of variation, was again high - 53.4%. The correlation coefficient and regression coefficient obtained in the study were .24 and .03% trash, respectively. Although both measurements were positive, neither was significant and their magnitudes were low.

Both studies showed the high amount of variability in trash %. In order to reduce the amount of variation it would be necessary that samples larger than 50 lb be taken. Based on earlier work 150 lb samples would give more reliable data on trash %. However, larger samples might not be economically feasible at mills due to increased labor requirements.

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WHAT CAUSES TRASH?

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Many of you may recall the old Jewish proverb "A man is wise when he searches for wisdom; when he thinks he's found it he's a fool". This is an appropriate preface because the title infers that someone will attempt an answer to the most widespread processing difficulty every mill experienced this year.

Recognizing this is a sensitive subject with some individuals; it is still worth the risk of being classified a fool since these sensitive individuals are the ones in need of help. Yesterday they were doing the talking, and today we have their captive attention, and hopefully they will be listening with open minds and admit privately there are some areas in their overall operations that, if improved, would result in reducing their trash.

It is my opinion that the answer to "What Causes Trash?" should first be qualified with a statement that nature has seen to it that an irreducible percentage of trash will always be present in cane. The answer to what makes trash excessive is simply man and machines. What man and what machines? The men and machinery used in today's field operations.

This is a basic fact, and for the time being forget about the 20% trash that should have been only 10%; forget about your doubting the honesty of the mill's sampling; forget about the mill's adherence to the sampling procedures and accept this statement as a fact - man and machines are causing excessive trash.

At St. James, our records prove that from year to year some growers are consistently high trash growers, while others with generally the same soil types, varieties, yields, equipment and size are consistently low in trash. Why? There must be an explanation, and the only apparent explanation is the differences in people and their management of some or all phases of the total field operations. Total field operations is defined as everything from digging ditches all the way through the harvesting of cane. Each and every operation can be a potential contributor to excessive trash and field managers should not forget this nor neglect their supervision of any operation.

LAND PREPARATION

This is generally not too difficult to manage, especially if the elements cooperate. Yet we find some growers neglecting their ditches, canals, and substituting quarter drains in lieu of crowning or leveling. We frequently see sawmill-size trees growing on the banks of main drainage canals. This is the kind of management that not only fails to achieve maximum yields but creates a condition where fields stay wet and take longer to dry. When heavy harvesting equipment moves in before these fields are dry, deep ruts and excessive top soil in cane are the results.

There are a few farms that neglect to properly supervise the marking or setting up of rows. Usually we find rows on 5'-10" to 6' centers. However, there are some farms where it is easy to find a row width mixture of everything from under 5'-6" to over 6' centers. Now stop for a moment and think about how this can seriously affect the loader operator's control of his piler.

Our observations indicate that farms with wider and higher rows usually sell less real estate. Both width and height are very important in row making.

VARIETY SELECTION

Management of variety selection can be frustrating and needs careful planning since this is a 3-year decision. We have found that farms with a high percentage of L 60-25 are usually high in trash. There is reason to believe that some varieties relate to higher trash and L 60-25 has this undesirable characteristic in addition to others. Surely most of you can recall the trash results from harvesting CP 55-30.

In the area of variety selection, we also have noted some questionable decisions with respect to variety and soil types. A considerable acreage of CP 61-37 was observed in heavy soils or what we call black land. Now apparently these growers did not read the bulletins from their County Agents or just ignored the information on variety characteristics. A late maturing variety harvested late in black land will historically mean trouble.

CUTTING

When grinding begins and the crop is standing erect, the cutting operation goes according to the textbook. But when the elements cause severe lodging, some operations just seem to fall apart. In some of these operations it appears the goal becomes get to the next headland. All of the concern they started with about doing a good clean job of cutting has now been put aside to achieve the newly acquired goal of get to the next headland. As a result, we see an excessive amount of cane not topped, rolled over, uprooted, dropped or scattered about on the heap row only through the mechanical ingenuity of the cane harvester. The harvester operators soon become so frustrated fighting toppler chokes that if someone welded the toppler in the upper position it would not affect the harvesting operation or the cane quality.

Now there are others who cut slowly one way, have installed an improved toppler and made many other modifications to adapt their machines to the general harvesting conditions. As they move from field to field they continue to make minor adjustments to meet particular conditions. From a cane quality standpoint, their cane is usually more desirable than the get to the next headland bunch.

How much should I cut ahead? This is a frequent question for discussion and very few growers are ever able to comply with their desired plans. In most cases, the result turns out to be an excessive amount of cane cut compared to their normal daily deliveries. Agreed, this is very difficult to control because there are so many variables. However, control and supervision of cutting is absolutely necessary.

Some growers, unfortunately, are still of the old school of cutting to get a good lead in case of a harvester breakdown. This good lead has been as much as 3 to 4 days ahead of loading and possibly more in some instances. These growers are sometimes proud of their trash records while the mill is having problems in fabrication. The good lead theory is a bad harvesting practice which, in some cases, is mill inspired.

BURNING

Under the moist field conditions experienced this past crop, many growers found that green cane would burn much better when set on fire immediately after cutting. If the burning was delayed until the following day, the dry shuck in contact with the moist ground absorbed moisture much like a sponge and would not burn completely. With this being our basis, we're tempted to conclude that the common 2-day practice (cut today, burn tomorrow) was not valid and was actually working against reducing trash during this past grinding season.

When rain enters the weather picture, we have observed some panic-stricken reactions to get an extra day cut and burnt in anticipation of rain. Should the rain arrive on schedule, this reaction was the proper one, presuming a reasonable quantity of cane cut is involved. We occasionally find, though, the weather is unpredictable and the rain fails to arrive as forecast or does not amount to more than a light drizzle. This does not seem to stop the harvesters.

A real sad situation is where we find a stretch of 2 or 3 cuts long that was maybe half or two-thirds cut at quitting time. That night it rains to the extent there's little hope of burning this cane for 2 or 3 days and then only partially. The usual grower response was that he feared the fire would cross over into the uncut or standing cane which may be 5-10 rows. It's easy to predict the usual grower response after hauling this unburnt cane and looking at the 30% trash results.

Surely growers are aware that standing cane dries rapidly following a rain and quicker than most people realize. I know of one grower who will not cut in anticipation of rain for over the years he has found that he can deliver better quality cane in the long run by waiting to cut and burn after a rain. This grower is consistently a low trash grower.

LOADING

There are some growers who do an excellent job of managing and controlling every field operation through the cutting, but permit or ignore poor loader operation. This is the phase of the total field operation capable of creating the biggest processing difficulty for a mill and yet, receives on a day to day basis, the smallest manhours of supervision on a farm.

It is not possible to eliminate the real estate being picked up with today's loading equipment. The incompetent or careless operator can easily make this problem excessive particularly if his friends are scrapping behind him, or if the field manager is complaining about the scrapping he's causing.

We know of a case where a grower, perhaps unknowingly, converted a good loader operator into a careless operator. He did this by giving a day's pay for only 5-6 hr of work. He has a good hard working crew that's in a hurry to knock off early. The records will prove that this grower is consistently high in trash.

CANE QUALITY

Every processor knows there are very few growers who will admit delivering cane containing excessive trash. To do so would mean this grower is admitting he has an imperfection and this would be in violation of his built in defense mechanism. We wonder how many processors will admit they were responsible for some of the poor quality cane they ground this past grinding.

The growers can not provide the kind of cane the processors demand. The processors say they want clean, well burnt, fresh cane and they don't want that trashy--- that has connotations of unpleasant odors. Now if the processor really wants well burnt clean cane, he's wrong if he complains about old or stale cane. If the processor really wants fresh cane, he's wrong if he complains about trashy cane. It is just not possible today to consistently supply clean, fresh cane since the 2 are compatible only after a freeze.

So there exists a communication dilemma between growers and processors. We believe if a processor was pinned down, he would admit that better results can be attained processing fresh cane with a reasonable amount of trash. The amount of trash considered reasonable would depend on field and weather conditions.

SUMMARY

Most people are aware that growers struggle from one obstacle to another and have their management talents too diluted to be fully effective in all areas of their operation. There are also many processors in this situation and some growers are frequently reminding them of their mistakes and deficient management.

Accusations will never solve the problem of excessive trash, and before any are made the famous Indian prayer should be recalled, "Grant that I may not criticize my neighbor until I have walked a mile in his moccasins".

No one is attempting to be critical, but only attempting to offer an opinion of the cause of excessive trash -- man in the field and the machines he uses to produce and harvest his crop. This man's management, methods, or decisions, will ultimately have a great influence on the quality of cane he delivers to his processor. If he neglects only 1 area of his total field operation he creates a potential trash problem.

The solution to this problem should not be too difficult for there are many growers doing an excellent job of supplying good quality cane under some very adverse conditions. They have resolved this problem by using good common horse sense -- the basic ingredient that separates individuals and the success they achieve.

SOME EFFECTS OF CANE TRASH ON MILLING QUALITY OF SUGARCANE^{1/}

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ABSTRACT

The effects of cane trash (mixture of 60% green tops and 40% dry leaves) in increments of 0, 5, 10, 20, and 30% by weight of cane on 7 components of milling quality - fiber % of cane, normal juice extraction, sucrose, and purity, D/L ratio (ratio of dextrose to levulose), and calculated yield of 96-pol sugar per gross and net ton of cane - were investigated. The effects of each of 4 kinds of cane trash - green tops, dry trash, a mixture of green tops and dry trash, and wet trash - on milling quality at 20% by weight of cane were also investigated. The influence of maceration water on the effects of cane trash on milling quality was also studied. A regression analysis of the combined results for the 1971-72 and 1972-73 milling seasons indicated that each 10% increase in cane trash caused a 1.8% increase in fiber % of cane, a 3.7% decrease in normal juice extraction, a 0.9% decrease in normal juice sucrose, a 2.8% decrease in normal juice purity, a 30 lb decrease in calculated 96-pol sugar per gross ton of cane, and a 17 lb decrease in calculated 96-pol sugar per net ton of cane. Cane trash also caused a lower D/L ratio, which could result in a low, or false, pol. Each of the 4 kinds of trash had a significant adverse effect on milling quality. The calculated loss of 96-pol sugar per net ton of cane was 22 lb caused by green tops, 14 lb caused by dry trash, 27 lb caused by the mixture of green tops and dry trash, and 43 lb caused by wet trash. Maceration water significantly increased the calculated yield of recoverable 96-pol sugar per ton of cane by aiding normal juice extraction. However, maceration water significantly lowered normal juice purity.

INTRODUCTION

Not since the early 1940's and the advent of the mechanical harvester has there been so much concern over cane trash and milling quality. Cane trash is any material from which no sugar is obtainable when delivered to the mill. Cane trash includes cane leaves, tops, roots, soil, weeds, water, tramp iron, etc. (1). However, in our studies, only that trash contributed by the mature stalk cut at ground level - its leaf blades and sheaths, wet or dry, and the growing top of the stalk itself - was considered. The average trash content of hand-cut, hand-stripped, and hand-loaded cane seldom exceeded 4% before 1942. However, because of the wartime shortage of field labor, growers sought an alternate method of harvesting their crop. As the number of mechanical harvesters increased, there was an increase in the cane trash and field soil being delivered to the mills (14). By 1947, trash levels at the mills nearly doubled those of prewar years. This prompted numerous investigations into the effects of cane trash on juice quality (2, 4, 7, 14, 18, 19), millability and losses of sugar in bagasse (9, 10, 13, 17, 20), clarification (5), sugar recovery (2, 14), and the value of delivering trash-free cane to the mill (6, 8, 12).

Initial investigations (4) in 1942 indicated that trash (8.5% by weight of cane) did not adversely affect sucrose extraction, but did affect the quality of the clarified juice. Others (9) showed a purity drop of 6.2% between dilute and residual juices for trashy cane (10.6% trash) and only 3.9% for clean cane (1.6% trash). This indicated that more impurities are extracted from trashy cane.

In a later study (2), the effect of cane trash reported to be most significant was on juice purity and, inferentially, on sugar recovery. Dry trash (8.6%) resulted in the calculated loss of 0.6 lb sugar for each 1% of trash, and green trash (18.4%), not to include tops or portions of tops, resulted in a calculated loss of 0.5 lb sugar for each 1% of trash. Sugar losses were also associated with the retention of sucrose in bagasse.

In 1948, Keller and Seip (14) investigated the effects of trash on declining sugar recoveries. Their data were obtained from several commercial mills operating in Louisiana. It was their opinion that lower recoveries were directly correlated with mechanization and the resulting increase in trash being delivered to the mills. The highest trash level in their report was 9.8%. They stated that any attempt to relate trash to yield deficiency resulted in factors of dubious value.

Coleman (7) observed that the presence of wet trash in harvested sugarcane diluted the juice and reduced juice purity through the extraction of its non-sucrose solids. Work in Taiwan (18) showed that, for each 1% increase in cane trash, there was a 0.6% drop in juice purity.

^{1/} These studies were initiated at the request of the American Sugar Cane League.

In most of these studies on cane trash, the amount of trash - tops, leaves, roots, soil, etc. - by weight of cane was no higher than 10%. The effects of trash on milling quality were measurable but considered insignificant. Industry records of the past 2 years have reported trash contents of 30% and higher. Our experiments on the effects of cane trash were begun because no investigations have been reported with such high levels of trash. No attempt was made to study the combined effects of field soil and cane trash. Studies were also conducted on the effects of cane trash on the D/L ratio (ratio of dextrose to levulose), the effects of 4 kinds of cane trash on milling quality, and the combined effects of cane trash and maceration water on milling quality.

MATERIALS AND METHODS

Cleaned samples of sugarcane were milled (3), with known quantities of cane trash added. Cleaned samples of cane were also milled without trash as controls. Both cleaned cane and trash were chopped individually into pieces of 6-10 in. in length to insure a uniform distribution of cane and trash when samples were reconstituted for milling. Each sample was passed 4 times through a 3-roll (10 x 14 in. rolls) Squier mill with 30 tons hydraulic pressure on the top roll. Unless otherwise stated, simple maceration water was applied in 3 equal portions after each of the first 3 millings. Crusher juice was weighed and samples taken after the first milling. Crusher juice was then discarded. The mixture of maceration water and cane juice (mixed juice) collected from the final 3 millings was weighed, well mixed, and sampled. The samples of crusher and mixed juices were analyzed, using a hydrometer to determine brix, polarization to determine apparent sucrose, and appropriate calculations to determine purity, the ratio of sucrose to brix (16). Bagasse weights were recorded, and samples were collected for fiber determinations (16). Sucrose loss in bagasse was assumed to be 3%; no actual measurements were made. Data involving crusher-juice brix and sucrose, normal juice extraction, and sucrose reduction factors were used to calculate yield of 96-pol sugar per gross ton of cane (15); 96-pol sugar yields were recalculated on a net, or trash-free basis. (Further reference to yield of sugar per ton for both gross and net cane will be on a calculated 96-pol basis).

Four kinds of cane trash were used in these experiments: 1. Green tops - the top 6 in of the stalk with all attached foliage; 2. Dry trash - all foliar trash except for the green tops; 3. Mixture of 60% green tops and 40% dry trash - referred to as cane trash and simulates unburnt field trash; and, 4. Wet trash - foliar trash, with the exception of green tops, soaked in water about 2 hr before milling to simulate rain-soaked trash in unburnt cane, cut and properly topped in the field. Cane was cut from the field one day before milling to allow for sample preparation. The chopping of cane and trash was done the same day samples were milled.

The first experiment conducted in the 1971-72 and 1972-73 grinding seasons investigated the effects of cane trash on milling quality of the variety CP 61-37 in the plant-cane crop. On each of 3 dates during the 1971-72 milling season, Jan 6 and 13 and Feb 1, 1972, and 3 dates during 1972-73, Nov 28 and 30 and Dec 5, 1972, duplicate samples of cane stalks with 0, 5, 10, 20, and 30% cane trash were milled. In 1971-72, the total weight of each sample, including those with trash, was 80 lb. In 1972-73, the weight of cleaned cane stalks in each sample was 80 lb, and the sample weight varied according to the amount of trash added. In both years, the trash content was equal. Data were analyzed separately for each grinding season, and a combined analysis was made for the 2 grinding seasons.

A second experiment investigated the effect of cane trash on the D/L ratio (ratio of dextrose to levulose). On Jan 13, 1972, 6 samples of 80 lb each of cleaned sugarcane stalks of the variety CP 55-30 in the plant-cane crop were milled with the following amendments: Two samples each with 25% green tops; 2 samples each with 25% dry trash; and 2 samples each with no trash. Milling was done as previously described. From each sample of crusher juice, a subsample was taken for a gas-chromatographic separation of the sugars (11). On the same date, subsamples of crusher juice from the first experiment with CP 61-37 were also used for gas-chromatographic separation to investigate the effect of the different increments of trash on the D/L ratio.

A third experiment was conducted on Dec 29, 1972,^{2/} to determine the effects of different kinds of trash on milling quality. Twenty percent cane trash was added to duplicate 80-lb samples of cleaned, random stalks of the variety CP 61-37 in plant-cane in the following forms: 1. Green tops; 2. Dry trash; 3. Mixture of green tops and dry trash; and 4. Wet trash. Two samples were milled without trash as controls. Milling and the collection of data were as in the first experiment.

The objective of a fourth experiment conducted on Feb 4, 1972, was to determine the effects of cane trash and the need of additional maceration water on milling quality. Twelve 80-lb samples of cleaned, random stalks of the variety NCo 310 in the plant-cane crop were prepared and milled. Six samples had 30% trash added, and 6 samples served as controls. Duplicate samples with 30% trash were milled with maceration water in the amounts of 0, 20, and 40% by gross weight of cane. Also, duplicate samples with no trash added were milled with maceration water in the amounts of 0, 20, and 40% by gross weight of cane. The collection and analyses of milling data were as previously described.

^{2/} Late-season cane, only lightly affected by frost, was obtained from Valentine Sugar Co, Inc, Lockport, La.

RESULTS

A previous report (19) indicated that the approximate ratio of green tops to dry trash for most sugar-cane varieties was 6/4. In 1972-73, 20 samples of 20 stalks each of the variety CP 61-37 in the plant-cane crop were cut from the field at the soil level. Precautions were made not to remove any of the trash. Weighing of green tops and dry trash gave an average ratio of 57/43, agreeing with earlier results. Average % of total trash for the 20 samples amounted to 25.4.

Percent dry matter was determined for the 4 kinds of trash used in these experiments. Duplicate samples of each - green tops, dry trash, mixture of green tops and dry trash, and wet trash - were dried to a constant weight at 105 C. The average value for % dry matter for each kind of trash was 23.7% for green tops, 79.4% for dry trash, 46.0% for the mixture, and 27.4% for wet trash.

In a combined analysis of the 2 years' data for the first experiment, there was a significant increase in both bagasse and fiber % of cane at each successive increment of cane trash. The weight of bagasse more than doubled, and fiber increased by 56% (Table 1), as the level of trash increased from 0 to 30%. Fiber % of bagasse remained relatively constant for all treatments. As fiber % of cane increased at each level of trash, normal juice extraction was significantly decreased. At 30% trash, normal juice extraction was only 87% of that of the control with no trash. Both normal juice sucrose and purity were significantly reduced by as little as 10% of cane trash. This detrimental effect of cane trash was accentuated as the amount of trash surpassed 10%.

Table 1. Effect of cane-trash quantity on milling quality of sugarcane, variety CP 61-37.

Trash : Fiber %		Percent normal juice			Lb sugar per	
(%)	Cane	Extraction	Sucrose	Purity	Gross ton	Net ton
<u>1971-72 milling season</u>						
	(10.1) ^{1/} 2/	(84.6)	(17.2)	(91.2)	(278)	(278)
0	100 a	100 a	100 a	100 a	100 a	100 a
5	111 b	97 b	100 a	100 a	96 b	99 a
10	124 c	94 c	97 b	97 b	88 c	95 b
20	142 d	90 d	91 c	94 c	76 d	88 c
30	160 e	85 e	85 d	92 d	65 e	83 d
<u>1972-73 milling season</u>						
	(9.6)	(84.5)	(14.2)	(86.3)	(222)	(222)
0	100 a	100 a	100 a	100 a	100 a	100 a
5	113 b	98 b	96 b	98 a	92 b	95 a
10	124 c	96 c	97 a	99 a	91 b	97 a
20	139 d	92 d	89 b	95 b	77 c	88 b
30	151 e	88 e	80 c	89 c	62 d	77 c
<u>Combined seasons</u>						
	(9.9)	(84.5)	(15.7)	(88.8)	(250)	(250)
0	100 a	100 a	100 a	100 a	100 a	100 a
5	112 b	98 b	98 ab	99 ab	94 b	98 ab
10	124 c	95 c	97 b	98 b	90 c	96 b
20	140 d	91 d	90 c	94 c	76 d	88 c
30	156 e	87 e	83 d	91 d	64 e	80 d

^{1/} Figures in parentheses represent means for control.

^{2/} Values in table represent % when compared to control with no trash added. Percentages in individual columns followed by same letter are not significantly different at the 5% level.

Of particular importance was the cumulative effect of cane trash on milling quality. A significant reduction in yield of sugar per ton of cane was found at trash levels as low as 10%. At 30% trash, yield of sugar per gross ton of cane was but 64% of that from the control with no trash; yield of sugar per net ton was 80% of control.

The combined regression analyses for the 2 seasons (Table 2) showed the expected relationship of cane trash with fiber % of cane, normal juice extraction, sucrose, and purity, and yield of sugar per gross and net ton of cane for each 10% increase in cane trash. Of particular interest was the loss of sugar per ton of cane (30 lb per gross ton and 17 lb per net ton of cane) for each 10% increase in trash.

Table 2. Regression analyses showing the effects of each 10% increase in cane trash.

	Regression coefficients		
	1971-72	1972-73	Combined
Fiber percent of cane	+ 2.0%	+ 1.6%	+ 1.8%
Normal juice extraction	- 4.2%	- 3.2%	- 3.7%
Normal juice sucrose	- 0.9%	- 1.0%	- 0.9%
Normal juice purity	- 2.4%	- 3.2%	- 2.8%
Calculated 96-pol sugar			
Per gross ton	- 32 lb	- 28 lb	- 30 lb
Per net ton	- 16 lb	- 18 lb	- 17 lb

In the second experiment, preliminary results indicated that the D/L ratio (ratio of dextrose to levulose) is reduced by the milling of green tops (Table 3). Dry trash had little effect on the expression of the D/L ratio. The D/L ratio decreased as the level of cane trash increased from 0 to 30%.

Table 3. Effect of cane trash on the D/L ratio (ratio of dextrose to levulose).

Variety	Percent trash-disposition	D/L ratio
CP 55-30	None	1.83 ^{1/}
	25% green tops	1.46
	25% dry	1.88
CP 61-37	None	1.56
	5% mixture ^{2/}	1.41
	10% mixture	1.35
	20% mixture	0.95
	30% mixture	1.06

^{1/} Each value represents the mean of 2 replications.

^{2/} Mixture of 60% green tops and 40% dry trash.

In the third experiment, the effects of 4 kinds of cane trash were investigated. The percent trash in each case was 20% by weight of sample. Fiber % of cane was least influenced by green tops (Table 4). Dry trash caused a significant quantitative increase in the amount of fiber (184% of that of control). Either a mixture of green tops and dry trash or wet trash alone significantly increased the amount of fiber.

Table 4. The effects of 4 kinds of trash on milling quality of sugarcane, variety CP 61-37.

Trash ^{1/}	:Fiber %	Percent normal juice			Lb sugar per	
	: Cane	:Extraction	Sucrose	Purity	Gross ton	Net ton
	(11.2) ^{2/}	(85.6)	(14.8)	(86.4)	(235)	(235)
None	100 a	100 a	100 a	100 a	100 a	100 a
Green tops	107 ab	92 c	90 c	95 cd	79 b	91 c
Dry trash	184 d	80 e	95 b	96 c	68 d	94 b
Mixture	132 c	88 d	90 c	94 d	73 c	89 c
Wet trash	117 b	94 b	83 d	98 b	74 c	82 d

^{1/} Trash was added to each sample to constitute 20% by weight.

^{2/} Figures in parentheses represent means for control.

Normal juice extraction was least affected by wet trash (Table 4). Dry trash decreased normal juice extraction the most, to 80% of that of control. Green tops reduced normal juice extraction to 92% of that of control, 2% more than wet trash. The mixture of green tops and dry trash caused a reduction to 88% of that of control.

Normal juice sucrose was affected least by dry trash and most by wet trash (Table 4). The mixture of green tops and dry trash and the green tops alone caused reductions in normal juice sucrose equal to 90% of that of the control.

Wet trash had the least effect on normal juice purity (98% of that of control) (Table 4). The greatest effect on normal juice purity was caused by either the mixture of green tops alone (to 94 and 95%, respectively).

Results indicated that of the 4 kinds of trash tested, wet trash had the most serious effect on yield of sugar per net ton of cane (42 lb decrease, to 82% of that of control) (Table 4). Dry trash had the least effect - a reduction of 14 lb to 94% of that of control. Approximately the same losses could be anticipated from either a mixture of green tops and dry trash or green tops alone (23 lb decrease, to 90% of that of control).

In the fourth experiment, maceration water led to a recovery of the sugar that would have been lost in cane trash (Table 5). Maceration water had little effect on fiber % of cane in samples, with or without trash. However, maceration water greatly increased normal juice extraction from samples, with or without trash. Normal juice sucrose did not change with varying levels of maceration water. However, maceration water did significantly reduce the value of normal juice purity in samples, with or without trash.

Table 5. The influence of maceration water on trash effects on milling quality of sugarcane, vareity NCo 310.

Maceration water %	Trash %	Fiber %	Percent normal juice			Lb sugar per	
			Extraction	Sucrose	Purity	Gross ton	Net ton
	0	11.2	76.0	18.1	91.8	236	236
0	30	18.3	58.4	16.0	85.1	156	223
	LSD (0.05)	0.3	0.9	1.4	1.8	13	14
	0	11.1	83.4	17.7	88.4	276	276
20	30	17.2	67.7	15.2	82.4	173	247
	LSD (0.05)	0.3	0.9	1.4	1.8	13	14
0	0	11.4	83.7	18.0	89.3	284	284
40	30	17.2	70.7	14.7	81.6	176	252
	LSD (0.05)	0.3	0.9	1.4	1.8	13	14
LSD (0.05) ^{1/}		0.3	1.1	NS	2.1	16	18

^{1/} Same values for LSD (0.05) apply for both 0 and 30% trash.

DISCUSSION

Previous studies of the effects of cane trash on milling quality were, with one exception (2), limited to trash contents of 10% or less (4, 9, 14). None of these studies showed an appreciable loss of recoverable sucrose caused by trash. As the level of trash exceeds 10%, the effects on milling quality are more apparent. Our studies showed these effects include a significant increase in fiber and significant reductions in normal juice extraction, sucrose, and purity. Also, there was a tendency for a lower D/L ratio (ratio of dextrose to levulose) as the level of trash increased. The cumulative effect of cane trash was a significant reduction in the yield of sugar per ton of cane. Increase in amounts of cane trash showed a positive linear relationship for fiber and a negative linear relationship for normal juice extraction, normal juice sucrose, and normal juice purity, and sugar per ton of cane. We show that increments of cane trash of more than 10% cause increasingly greater losses of sugar per ton of cane. Actual factory losses may be even greater, because our formula for calculating sugar yields used a constant purity value of 28.6% for final molasses. Also, sucrose levels in bagasse for the higher increments of trash may exceed the 3% value used in these studies.

Trash consisting only of green tops did not significantly increase fiber % in cane because of similar dry-matter values for clean cane and green tops. This was on a gross-cane basis.

Arceneaux and Davidson (2) indicated that green trash (only older green leaves) increased the normal juice extraction on a net-cane basis. In our studies, green tops gave a similar increase in normal juice extraction on a net-cane basis; a decrease occurred when these results were put on the gross-ton basis that factories use in computing normal juice extraction.

Twenty percent trash of green tops only reduced the values for both normal juice sucrose and purity. We observed that green tops caused the clarified juice to have an objectionable dark color. Green trash in cane gave a lower D/L ratio than did trash-free cane or cane with dry trash. A low D/L ratio could result in a low, or false, pol.

Twenty % trash of green tops only caused the least reduction of sugar per gross ton of cane. However, when sugar yields were recalculated per net ton of cane, 20% trash of green tops only caused a significant reduction.

Arceneaux and Davidson (2) found that dry trash caused an increase in bagasse and fiber % of cane and a reduction in normal juice extraction. Our results confirmed these findings.

Twenty % dry trash did not greatly affect the value of normal juice sucrose; it did introduce significant impurities and non-sucrose solids into the juice, reducing the value of normal juice purity.

The loss of sugar per gross ton of cane caused by dry trash was serious. This was because of the decrease in extractable normal juice and the lowered normal juice purity.

Recalculated on a net-ton basis, the cumulative effect of dry trash on sugar yields was not as serious. Dry trash had the least effect on sugar yields per net ton of cane.

A 20% mixture of green tops and dry trash caused a significant increase in both bagasse and fiber % of cane. However, this increase was not as great as found for dry trash. The bad effect of the trash mixture on fiber % of cane and on normal juice extraction was in proportion to the amount of dry trash added.

When green tops and dry trash were mixed, the effect on normal juice sucrose and purity was additive. Both normal juice sucrose and purity were reduced more by the mixture than by either green tops or dry trash alone.

The loss of recoverable sugar per gross ton of cane from the mixture of green tops and dry trash was intermediate between the losses from either green tops or dry trash alone.

The cumulative effect of the mixture of green tops and dry trash on sugar per net ton of cane was also additive, with the resulting loss being greater than that from either green tops or dry trash acting alone.

Machine-cut rain-soaked cane was simulated by soaking dry trash in water for about 2 hr before milling. The wet trash then contained 27.4% dry matter and caused only a slight increase in fiber % of cane. Also, with the high moisture percent of wet trash, there was little reduction in normal juice extraction.

Wet trash seriously affected normal juice sucrose by dilution, confirming earlier work by Coleman (8). However, there was only a slight increase in extracted impurities and non-sucrose solids from the cane mat, resulting in a slightly reduced normal juice purity.

The effect of wet trash on sugar per ton of cane was serious. The loss per gross ton of cane was equal to the loss from milling cane with a mixture of green tops and dry trash. However, the loss per net ton of cane incurred by milling wet trash was the greatest of those from the 4 kinds of trash tested.

Our results indicated that 30% cane trash doubled the volume of bagasse and increased fiber by as much as 56%. To compensate for added fiber, mills increase the amount of maceration water (16). We showed that 30% cane trash could cause losses in recovery. However, when 20% maceration water was added, sugar recoveries were significantly increased. Increasing maceration water from 20% to 40% by weight of cane only slightly improved sugar recoveries. While the cumulative effect of maceration water was beneficial, maceration water did significantly reduce the value of normal juice purity.

Besides the deleterious effects of cane trash on milling quality, trash can cause many other problems to growers and processors (8, 9, 18). Trash increases the gross tonnage handled by the grower, thus increasing hauling costs. It decreases milling capacity, increases wear on mill rolls and juice and mud pumps, decreases sucrose extraction, and causes difficulties in clarification and evaporation. Trash causes additional losses of sucrose in a greater volume of higher purity final molasses. Processors notice a decrease in sugar quality when processing excessive amounts of trash. Trash increases the fuel cost.

Wet and rainy weather is normally associated with high trash content (5), and it is then that the losses of recoverable sugar are greatest. Consequently, the combination of cane trash with mud and other extraneous material would cause additional losses not covered in the discussion of this paper.

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DETERIORATION IN WHOLE AND CHOPPED SUGARCANE^{1/}

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ABSTRACT

Comparisons were made in the deterioration rates of chopped and whole-stalk sugarcane. Deterioration was measured by changes in brix, sucrose, purity, acidity, and gum content. Deterioration rates as affected by size of stalk pieces, strain of bacteria, burning, freezing, variety, and type of cut were measured. Deterioration rates were inversely related to size of stalk piece and were hastened by burning or freezing. Variety differences in deterioration rates of chopped cane were found. Unburned or unfrozen cane harvested by chopper-harvesters should be ground 1 to 2 days after harvest, depending on size of cut stalk pieces.

INTRODUCTION

Record amounts of trash and mud in harvested sugarcane during the 1971 and 1972 seasons led to field and processing losses (15). Interest in a chopper-harvester system for Louisiana has been renewed since mud and trash are reduced when cane is not placed back on a muddy field and is mechanically cleaned of leafy trash. Chopper harvesters were adopted in Australia when cane farmers converted to mechanical harvesting during the 1960's. Processing difficulties readily developed, and in 1962 Egan (4) observed sour storage rot as the primary cause of trouble. Rapid deterioration of cane was caused by Leuconostoc mesenteroides (Tsenkovsky) van Tieghem, a common bacterium that enters the cane pieces at the instant of cutting (6) and produces a sugar polymer, dextran.

The deterioration of chopped cane is accompanied by a rapid increase in dextran (5, 6, 13). When ground, deteriorated cane causes process liquids to increase in viscosity (8), with a decrease in factory capacity. Increases in dextran in chopped cane are accompanied by slower clarification and mud filtration. Sugar losses in processing due to dextran are indicated by the correlation of the dextran content of process liquids and final molasses purity (12, 21). Inhibition of crystallization of sucrose by dextran results in the formation of needle grain (sucrose crystals elongated on the C axis) (19, 20, 21). The effect of dextran continues through the processing system; gums may be occluded in the raw sugar crystals (2) and cause poor filterability and needle grain in the refinery.

Deterioration has been spectacular in chopped cane, with quality losses evident in 24 hr (1, 15), or even 14 hr (13). In Australia, daily deliveries of fresh cane that had been burned standing and harvested with chopper harvesters, gave no trouble. However, when this cane was stockpiled over the traditional shutdown for the weekend, processing difficulties were serious (4, 12).

Since the mechanization of harvesting in Louisiana in the 1940's, post harvest deterioration has caused serious losses. Lauritzen (14) attributed these losses to dehydration and to the inversion of sucrose in burned, stale cane. An industry crisis was averted as growers learned to delay the burning of machine harvested cane until rapid movement to the mill was assured. In addition to losses of weight and sucrose, stale cane juices were found to contain a gum called sarkaran (3), which increases process liquid viscosity but does not affect crystal elongation (20).

Cane freezes often in Louisiana and rapid deterioration follows. This deterioration is characterized by an increase in gums (10). When juice is processed from frozen cane, complete inhibition of crystallization may prevent the recovery of anything but molasses. Dextran, a natural gum, has long been associated with difficulties in processing frozen cane (7, 23). Needle grain is a familiar sign of processing losses due to frozen cane. Louisiana farmers cooperate with the mills by topping frozen cane lower to improve quality and prevent the premature closing of mills.

Natural gums, a broad class of polymers of several sugars, occur in normal (18), stale (3), frozen (10) and chopped cane (4). Gums from cane in these various states differ in chemical composition (3, 18). Increased gum content is associated with refractory process liquids and needle grain, but it is not known whether sugar losses are directly related to gum concentration, or whether there is a threshold beyond which crystallization is inhibited. Gums are expressed as a part of raw juice, or, more realistically, as percentage of solids (brix) or percentage of sucrose. The amount of gum in processing liquids that might indicate the beginning of processing difficulties is not known.

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Dextran, a polymer of glucose with a 1-6 glucosidic linkage, is the product of the action of species of Leuconostoc on sucrose. Different strains of L. mesenteroides cause different rates of deterioration, and different strains also produce dextrans of different molecular weights (6). Dextrans of increasing molecular weights cause increasing crystal elongation of sucrose (20). When added experimentally to process liquids, as little as 1 part of dextran to 200 parts of sucrose (0.5% dextran) can slow crystallization (12). Dextran has been isolated from frozen and chopped cane (13, 21, 23).

A series of experiments was conducted to assess the potential deterioration hazards in a chopper-harvester system for Louisiana conditions. These experiments are the subject of this paper.

MATERIALS AND METHODS

The first experiment was begun in February, 1972, with field grown sugarcane lightly damaged by frost. Stalks of L 62-96 were topped so that no frozen tissue was included. The stalks were hand cleaned and were grouped in 40 10-stalk samples. Four samples were ground as controls, 12 were retained as whole-stalk samples and the other 24 samples were cut into 6 in or 15 in pieces with cane knives. Six samples each of 6 in, 15 in and whole (70 in) stalks were sprayed with 5400 ml of a culture of L. mesenteroides containing approximately 2.3×10^6 bacteria per ml. The other samples were left unsprayed. Three samples of each treatment, sprayed and unsprayed, were ground 1 and 5 days after spraying. Whole stalks and pieces were examined for L. mesenteroides 6 hr, 1 day and 5 days after spraying; sodium azide agar (17) was used as a diagnostic medium.^{2/} Crusher juice samples were assayed for brix, sucrose, purity, and gums. Gums were analyzed by the modified method (9) of Roberts and Friloux (18).

A second experiment was begun on Oct 19, 1972, using machine harvested L 60-25. Again, sizes of stalk pieces and levels of bacteria were tested. In this experiment, whole-stalk cane was compared with cane prepared by a rotary chopper built by Cane Machinery Co. Adjustment of the chopper to produce a short stalk piece and a long piece yielded average sizes of 7.3 and 9.7 in, with considerable overlap. Control samples and samples for the low bacteria level were unsprayed; samples for the high bacteria level were sprayed with a culture of L. mesenteroides collected at Thibodaux, La. Samples were sprayed 4 hr after chopping. Samples were kept at a high humidity and at 84 F, and were ground 6 hr, 1 day, and 5 days after cutting. Sample juices were analyzed as in the previous experiment.

A third experiment of the relation of stalk piece size with the rate of deterioration included a comparison of burned and unburned cane. Fresh, hand-cut stalks of L 60-25 were used; half of them were burned in a heap row and half left unburned. Five 10-stalk samples of burned and of unburned cane of 9 in pieces, 16 in pieces and whole stalks were ground on Nov 13, 1972, 6 hr after chopping with a rotary chopper. Similar samples were ground 1 and 2 days later, and sample juices were analyzed as in the previous experiments.

A fourth experiment of stalk piece size included 2 temperatures as variables. The 3 sizes of stalk pieces (averaging 9 in, 17 in, and whole stalks) were maintained, as usual, at high humidity at 84 F, and similar samples were kept outdoors at ambient temperature (64.5 F). Five 10-stalk samples of CP 52-68 were ground 2 hr and 1, 2, and 3 days after they were cut with a rotary chopper. Juice samples were analyzed as before.

A comparison of cutter types was made using the intermediate stalk size (17 in) kept outdoors in the previous test with whole and chopped stalks of NCo 310. Whole-stalk samples were cut at intervals on a row, then a chopper harvester (J. & L. Engineering Co.) operated over the same row to give samples averaging 18 in. The samples were analyzed over a 6-day period during their storage at outside temperatures. The chopper harvester was equipped with counter-rotating, circular knives for chopping the stalks into pieces.

To test the possibility of bacteria strain differences affecting the rate of deterioration of samples of L 60-25, we collected L. mesenteroides at 3 sugar mills, and these isolates and 1 from Louisiana State University were included in a comparative study. Bacterial colonies were isolated on sodium azide agar (17), and liquid cultures were prepared from these. The cultures were diluted 1:1 with distilled water and applied with a pressure sprayer as inoculum 6 hr after the pieces were cut. Inocula contained a minimum of 2.6×10^6 bacteria per ml. The spray was applied to pieces averaging 7 and 10 in long, and samples were ground 1 and 5 days after inoculation on Oct 19, 1972. Juice samples were analyzed as before.

The possibility of varietal differences in the rate of deterioration of chopped cane of 5 commercial varieties was tested. Whole-stalk samples were compared with pieces averaging 18 in long that had been cut by the rotary chopper. Samples were stored at high humidity (90-100% RH) at 84 F and were ground after 2 hr and 2 and 6 days after cutting. The varieties used were CP 44-101, CP 48-103, CP 52-68, L 60-25, and L 62-96. The varieties were taken simultaneously from a replicated yield trial.

A test of environmental stress was conducted with stalks of CP 52-68 that had been lightly damaged by a 25 F freeze. Ten samples, each with 10 stalks, were prepared as follows:

^{2/} Identification and isolation of L. mesenteroides was developed by Hideo Koike and Faye Seaberg of this Station.

- a. whole stalks with the frozen tops left intact.
- b. whole stalks with frozen tops removed.
- c. whole stalks with frozen tops removed and stalks burned.
- d. whole stalks with tops intact and refrozen so that 1/2 to 2/3 of the stalk tissue was damaged.
- e. each treatment (a. - d.) was repeated and the stalks were cut into 18 in pieces with a rotary chopper.

Whole-stalk and 18 in samples were prepared from each treatment and they were stored at 80 F. Samples were ground 1 and 3 days after treatment. In addition to the previous assays, sample juices were also analyzed for pH and titratable acidity.

RESULTS

Spraying stalk pieces of L 62-96 after chopping indicated that movement of bacteria through the stalk was related to size. The central tissue of the middle internode of whole stalks were free of *L. mesenteroides* 2 days after inoculation. The central tissue of the middle part of 6 in and 15 in pieces contained bacteria 6 hr after cutting. Deterioration after spraying was not measurable until after 1 day. Even then, gum content in both sprayed and unsprayed whole stalks of cane did not change significantly (1.2 mg/ml juice). Gum content did not change in 15 in cane pieces, but increased slightly in 6 in pieces (up to 1.8 mg/ml juice). Five days after spraying, gum content increased slightly in 15 in pieces (1.6 mg/ml), but increased greatly in 6 in pieces (2.6 mg/ml). Brix, sucrose or purity did not change significantly.

When this experiment with standover cane in the spring of 1972 was repeated in the fall of 1972, hand chopping was replaced with mechanical chopping. Again, both sprayed and unsprayed whole stalks showed no real deterioration (Table 1). Mechanically chopped cane showed rapid deterioration. Although cane was chopped into 2 average sizes, they were not greatly different and did not show a difference in the rate of deterioration. As in the first experiment, stalk and pieces sprayed with large amounts of bacteria showed a slightly greater rate of deterioration.

Table 1. Effect of chopping and levels of bacteria on rate of deterioration of whole and chopped sugarcane.

Treatment and storage period	Gums (mg/ml)		
	Whole stalk	10 in pieces	7 in pieces
<u>Check</u>			
0 day	1.69 a	1.55 a	1.57 a
<u>Unsprayed</u>			
1 day	1.10 a	4.42 b	3.28 b
5 days	1.70 a	4.40 b	3.66 b
<u>Sprayed with Leuconostoc</u>			
1 day	2.60 a	5.62 bc	2.04 ab
5 days	1.50 a	6.44 c	6.16 c

In the third experiment that compared stalk piece sizes with deterioration in burned and unburned cane, whole-stalk cane showed changes in brix, sucrose, and purity, and a slight, but significant increase in gums. Both 9 in and 16 in pieces of chopped cane showed a decrease in purity in both burned and unburned cane. Only 2 days after harvesting and chopping 9 in burned cane was unacceptable (Table 2). Gums in smaller pieces were higher than in whole cane, and gums in burned cane of all sizes were higher than in unburned cane.

Table 2. Effect of size and burning on the rate of deterioration of whole and chopped cane.

Treatment	Whole stalk	Gum Content	
		16 in pieces <u>mg/ml</u>	9 in pieces
Unburned stalks			
Check	0.89 a	0.81 a	0.71 a
2 days	1.01 a	2.88 b	3.63 b
Burned stalks			
Check	0.91 a	0.83 a	0.71 a
2 days	1.07 a	3.78 b	4.77 c
<u>% solids</u>			
Unburned stalks			
Check	0.51 a	0.48 a	0.43 a
2 days	0.89 a	1.85 b	2.22 b
Burned stalks			
Check	0.52 a	0.48 a	0.42 a
2 days	0.63 a	2.27 c	2.91 b
<u>% sucrose</u>			
Unburned stalks			
Check	0.57 a	0.53 a	0.50 a
2 days	0.69 a	2.27 b	2.60 b
Burned stalks			
Check	0.59 a	0.54 a	0.46 a
2 days	0.72 a	2.71 b	3.52 c

The fourth experiment of stalk piece size included 2 temperature levels. Samples for gum analyses for the 84 F treatment were mixed; thus comparison of temperature effects were impossible to make.

Data for the 16 in pieces in this experiment were from CP 52-68 cut by a rotary chopper. These data were compared to those from the 18 in pieces of NCo 310 prepared by counter-rotating, circular blades, in an experiment to contrast cutter types. Gums in whole stalks of the 2 varieties differed slightly after 3 days, but gums in cane chopped by the 2 cutter types did not differ (Table 3).

Table 3. Comparison of cutter types and gum content (mg/ml) of whole and chopped sugarcane.

Treatment	Whole stalk	Chopped pieces
<u>Rotary blades</u>		
(CP 52-68, 12-4)		
Check	0.91	0.80
1 day	1.28	1.16
3 days	1.57	3.36
<u>Counter rotating, circular blades</u>		
(NCo 310, 12-11)		
Check	1.63	1.41
1 day	1.60	2.96
3 days	2.27	3.66

Samples of bacteria collected from 4 locations and isolated by the sodium azide technique were all identified as L. mesenteroides. Gums in cane sprayed with these cultures averaged 5.4 mg/ml gums 1 day

after spraying and 5.2 mg/ml 5 days after spraying. Gums, brix, sucrose and purity between samples inoculated with any of the 4 collections of L. mesenteroides did not differ significantly.

Several differences were observed in the deterioration rates of the 5 commercial varieties. Whole stalks showed no significant changes in brix, sucrose or purity up to 6 days after harvest. Chopped pieces showed significant purity decreases in all varieties (Table 4). Gums in whole stalks of each variety increased significantly 2 days after harvest; gums in 2 varieties showed further increases 6 days after harvest. Although statistically significant, these differences were of little practical importance. Gums in chopped pieces of each variety greatly increased 2 days after harvest; gums in 4 of the 5 varieties further increased 6 days after harvest. The rate of increase in gums differed significantly (Table 5). The rate of increase was lowest (+ 1.2 mg/ml) in L 62-96, the variety with the highest initial gum content. The rate of increase was highest (+ 3.9 mg/ml) in L 60-25.

Table 4. Effect of varieties and purity changes in whole and chopped cane.

Variety and storage time	Purity	
	Whole stalks	Chopped pieces
CP 44-101		
Check	82.79 a	83.32 ab
2 days	85.78 ab	80.36 a
6 days	83.43 a	78.04 a
CP 48-103		
Check	89.36 b	88.27 c
2 days	88.28 b	88.81 c
6 days	84.97 ab	83.48 ab
CP 52-68		
Check	83.62 a	86.42 b
2 days	85.65 ab	82.72 ab
6 days	80.60 a	77.80 a
L 60-25		
Check	88.77 b	90.97 c
2 days	90.30 b	88.85 c
6 days	85.16 ab	82.72 ab
L 62-96		
Check	89.70 b	91.40 c
2 days	90.18 b	88.54 c
6 days	87.47 b	81.98 ab

Table 5. The effects of varieties on rate of deterioration of whole and chopped cane.^{1/}

Variety and storage time	Gum content			
	mg/ml		% sucrose basis	
	Whole stalks	Chopped pieces	Whole stalks	Chopped pieces
CP 44-101				
Check	1.47	1.96	1.11	1.38
2 days	1.92	3.50	1.26	2.68
6 days	1.91	4.33	1.23	3.44
CP 48-103				
Check	1.37	1.42	0.88	0.90
2 days	1.69	2.84	1.09	1.81
6 days	2.01	4.14	1.22	2.81
CP 52-68				
Check	1.44	1.71	1.03	1.16
2 days	1.93	4.10	1.28	3.06
6 days	2.27	4.66	1.56	3.74
L 60-25				
Check	1.34	1.59	0.82	0.95
2 days	1.73	4.54	1.04	2.91
6 days	1.90	5.49	1.14	3.77
L 62-96				
Check	1.90	2.44	1.14	1.43
2 days	2.39	3.76	1.34	2.36
6 days	2.44	4.19	1.44	2.48

^{1/} LSD = 0.34 mg/ml at 5% and 0.44 mg/ml at 1% level by using a pooled error mean square.

Whole stalks that had been lightly frozen in the field, but with the frozen tops removed, had a gum content of 2.6 mg/ml 3 days after harvest; similar cane chopped into 18 in pieces had a gum content of 4.5 mg/ml at the same time. When the same cane was burned, gums increased slightly (Table 6). Gums in whole stalks with tops intact were abnormally low; gums were higher in chopped pieces of this cane than in either burned or unburned cane. When the lightly frozen cane with tops intact was refrozen so that 1/2 to 2/3 of the stalk tissue was damaged, deterioration was much more rapid. Gums in whole stalks increased significantly 3 days after harvest and gums in chopped pieces of the same material was twice that of any other cane tested.

Table 6. Effects of burning, sour tops, and freezing on rate of deterioration of whole and chopped cane, after 3 days of storage.

Treatment	Gum content	
	Whole stalks	Chopped pieces
	mg/ml	
Normal stalks	2.55 a	4.50 a
Burned stalks	2.45 a	4.75 a
Sour tops	1.84 a	5.51 a
Frozen stalks	3.47 a	10.26 b
	% solids basis	
	Normal stalks	1.41 a
	Burned stalks	1.29 a
	Sour tops	1.05 a
	Frozen stalks	2.04 a
	% sucrose basis	
	Normal stalks	1.68 a
	Burned stalks	1.53 a
	Sour tops	1.28 a
	Frozen stalks	2.54 a
		2.62 a
		2.66 a
		3.44 a
		6.58 b
		3.24 a
		3.27 a
		4.39 a
		8.74 b

DISCUSSION

Chopped sugarcane is naturally inoculated by the harvester knives, and even immediate immersion in a bactericide does not prevent deterioration (6). Our results indicate that spraying with inoculum after cutting is effective and the rate of deterioration and the size of stalk piece remain inversely related. Deterioration progresses with natural inoculation and is more rapid if the bacterial population is increased.

The level of gums causing processing difficulties is not precisely known. In other work reported in these Proceedings, chopped cane kept 4 days under very cold conditions was used to produce A and B sugars with no crystal elongation (19). This cane had 0.7 mg/ml gums and 0.16 mg/ml dextran (0.11% brix). Sutherland and Patton (20) showed that dextran levels of 0.5% (sucrose basis) could cause elongation of sucrose crystals. Total gums include not only dextran with 1-6 and sarkarans with 1-4 glucosidic linkages, but also other polymers of pentose and hexose molecules (3, 18). When other related compounds are present, dextran is not the sole cause of crystal elongation and slowed processing. Sarkarans from stale cane slow processing; other gums from normal cane may contribute in proportion to their abundance.

A group of carbohydrates of intermediate molecular size, the oligosaccharides, contains compound sugars that may be associated with deterioration. Raffinose forms during the storage of sugarbeets, and at level above 0.5% (sucrose basis) sucrose crystals become deformed. Needle grain appears at levels above 2% (16). When added to sugarcane process liquids, oligosaccharides increased crystal elongation (11). One oligosaccharide has been found in the juice of stale cane, 4 of these compound sugars have been found in raw sugar, and 5 in final molasses (22). The role of oligosaccharides in the deterioration of chopped or frozen cane is not known. Egan (4) reported average gums of 2.3 mg/ml of juice for chopped cane held over but ground with minimal delay. He reports deteriorated holdover cane to average 4.7 mg/ml. This latter figure is similar to gums in samples from a Louisiana factory grinding frozen cane and unable to make sugar without remelting. Gums in samples from cane and mill juices from this factory ranged from 3.6 to 8.4 mg/ml with an average of 4.7. Final molasses contained 2.8% dextran (on sucrose). A second mill grinding at the same time was able to make A, B, and C strikes with some elongation in the C strikes. Gums in cane samples and factory juices averaged 3.2 mg/ml. From these observations, apparently total gums of about 4 mg/ml or higher indicate processing difficulties.

Data in this paper indicate that deterioration is most rapid in small (6 in to 9 in) pieces, less rapid in longer pieces (16 in to 18 in) and not a real problem in whole stalks during the short test periods. This confirms for Louisiana the results found in other areas (5). However, the rapid deterioration of small pieces should be balanced by the possible gain from a greater load density. Stalk pieces averaging about 8 in long may give a load density equal to that of Louisiana whole-stalk cane loads (about 20 lb/cu ft). Problems related to processing deteriorated cane can be avoided if chopped cane averaging 16 - 18 in is ground no later than 2 days after harvest; chopped cane averaging 8 in should probably be ground no later than 1 day after harvest, especially during the initial, warm weeks of the harvest season.

The fact that no differences in deterioration could be attributed to strains of *L. mesenteroides* from 4 locations might indicate that variations in deterioration of chopped cane from different areas would be due to factors other than strain differences. However, further study may identify strain differences.

The rapid deterioration in small pieces of chopped cane is further increased by burning, with gums in samples exceeding 4 mg/ml 2 days after cutting. All production chopper-harvesters usually operate in fields that have been burned to remove trash and speed harvesting. The combination of burning and chopping into small pieces has been identified as the main cause of sour storage rot in Australia (4, 13). Burning melts the protective wax on the cane stalk and causes localized death of storage cells in the stalk. Very hot burns may rupture the rind of the stalk. These results of burning promote bacterial invasion, proliferation, and, consequently, quality deterioration. Burning for chopper-harvesters in Louisiana should be avoided, and our wide row spacing and erect crop may eliminate the need.

The advent of chopper harvesters may require a revision of variety management practices. A popular variety for early harvest, L 60-25, shows a rapid rate of deterioration when chopped. Another early variety, L 62-96, has a slower rate of deterioration and may be adaptable to longer hauls or to overnight stacking. The use of a dual harvest system, combining soldier and chopper harvesters, will impose dual standards for harvesting different varieties. Should chopper-harvesters be used for a significant part of the Louisiana crop, new varieties would have to be evaluated for this system before release.

In comparison with chopper-harvesters, the soldier harvester has one critical advantage for subtropical sugarcane, and that is the ability to effectively remove cane tops. This operation alone removes 60% of the total trash on cane. Topping becomes more important after a freeze, for then the control that the operator has in setting the top cutter blade determines the amount of sour cane that goes to the mill. Since deteriorated, frozen cane may close affected mills, harvesters must be able to remove frozen, soured cane tops. Frozen cane deteriorates rapidly and experienced growers readily sacrifice tonnage for quality by lower topping. Because chopping promotes deterioration, frozen cane cut by chopper-harvesters must be hauled and ground without delay.

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MECHANICAL HARVESTING IN LOUISIANA:
THE EFFECT ON CANE QUALITY AND PROCESSING RESPONSE -- 1972 STUDIES

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ABSTRACT

These studies are part of a continuing industry, USDA, and Audubon Sugar Factory investigation covering (a) reevaluation of the current Louisiana whole-stalk harvesting system and (b) possible alternative harvesting and handling methods. The alternative system chosen for this investigation was a form of cut-chop combine harvesting. This initial phase of the investigation covered (a) cane quality as determined from small scale (100 lb) samples and (b) cane quality and processing response on a plant scale (2 to 3 tons). Cane quality criteria were the gum and dextran content and Leuconostoc mesenteroides count of the extracted juice. The small scale cane quality studies showed that, at ambient temperatures, unburned cane cleanly chopped into 20 in. billets showed better storage response than whole-stalk burned cane. At elevated temperatures, the reverse was true with more rapid deterioration of the chopped cane. The top section between the bud and the top mature joint showed a considerably higher gum and dextran content than the remaining whole stalk. At temperatures of 40 to 55 F, no significant change in cane quality or processing response was observed with cane conventionally harvested, left in the heap row, and processed over a period of 6 days. Due to equipment procurement delays, only one run was made with a prototype cut-chop harvester. This run was made in December on the variety NCo 310. After 5 days following cutting, cane quality still closely approximated that of a 100 lb hand-cut sample from the same row. Milling, clarification, and crystallization responses were excellent. Problems in milling and crystallization were encountered on a conventionally harvested run with the same variety but from a different plantation. This cane consignment was accompanied by a considerable volume of field soil, and deterioration between cutting and processing was evident. The relative processing response of cut-chop and conventionally harvested cane will be further investigated in 1973 on cane which is specifically from the same plot and of the same initial quality. Additionally, processing response data are needed during the warm humid early crop stages. Based on the above and other runs, gums and dextran are reliable indicators of cane quality as it would be reflected in subsequent processing. Tentative "threshold" values for these parameters are suggested.

INTRODUCTION

From the inception of the industry in Louisiana until World War II, harvesting and handling of sugarcane in the field consisted of manually cutting, topping, cleaning, and loading into field carts. Following World War II, shortage of field labor and rising labor costs resulted in a 100% conversion to mechanical harvesting and handling. The current Louisiana practice is to harvest mechanically by whole-stalk harvesters (cutting top and bottom), transfer the harvested cane to the heap row, burn in the evening or the next day as weather conditions permit, transfer from the heap row to tractor-carts by means of mechanical piler-loaders, and deliver directly to the factory for short hauls. For longer hauls, the cane in the carts is transferred to truck-trailers at transloading stations. Cane at the factory is either stacked in the yard for night grinding or transferred to the feeder tables for immediate milling.

Even under the best conditions, cane quality poses problems in the manufacture of sugar in the form of immature cane at the start of the crop with a large volume of undeveloped top sections in the stalks (due to the short growing season) and the prospects of a freeze and damage to the top cane sections in the latter crop stages. For these reasons, Louisiana harvesters must be equipped to top the cane. With immature green cane -- or during rainy spells -- burning does not satisfactorily remove the leafy foliage and this material accompanies the cane to the mill in an appreciable volume.

Additionally, for reason of economy the trend has been toward consolidation of smaller farming units and the utilization of larger heavy duty harvesters and loaders. These factors have posed problems in the coordination of cutting and delivery with the mill requirements and the supervision of the field operations. The result has been a marked increase in the incidence of stale or deteriorated cane, mangled cane, and a high volume of field soil, suckers, and loose tops. The volume of field soil is such as to require cane washing facilities at all the factories. The field soil problem is particularly critical in marginal heavy soil areas which have been brought into production with increasing acreage allotments and the loss to industry and urban requirements of prime cane land. This soil is high in clay content, and cane from these areas appears to have a higher incidence of uprooted stubble, the soil is difficult to remove in washing, and clarifier mud volume is correspondingly high.

As reflected in the processing, the current harvesting and handling system has provided a Pandora's Box of problems to include sugar losses in the yard, mill, and boiling house; capacity limitations at one or more of the factory stations; additional capital equipment, maintenance, and fuel costs;

problems in the disposal of solid and liquid wastes; and water and air pollution control problems. To these problems must be added the maintenance cost of field equipment as well as the problems incident to the burning of cane in the field.

The 1971 grinding season was a particularly wet one. This situation focused attention on a long overdue reevaluation of (a) the current system of harvesting and handling cane and (b) possible alternative harvesting and handling methods. To initiate such a study, meetings were held among representatives of the American Sugar Cane League, the US Department of Agriculture Houma Field Station, and the Audubon Sugar Factory.

The initial scope of the study was defined to include losses due to deterioration under the current and alternative systems of harvesting and handling, and the evaluation of new experimental harvesting systems. Louisiana farm machinery manufacturers were invited to participate in the project with prototype models of their equipment.

As developed in more detail, the studies involved a comparison of the conventional whole-stalk harvesting and handling system with a cut-chop combine type system. The scope of the studies included cane quality evaluation on a laboratory or sample mill scale and processing response on a factory scale of the harvested cane.

The US Sugarcane Laboratory at Houma has initiated in depth studies of harvested cane quality response to varying simulated climatic and storage conditions and chopped cane billet length and type of cut. The primary area of the Audubon Sugar Factory is the processing response of cane harvested by the conventional method and by alternative harvesting systems. The latter program was broadened to include small scale cane quality studies comparing whole-stalk burned and unburned cane with cane chopped to a billet length of 20 in.-- the length envisioned for a harvester which was to be field tested during the 1972 crop.

Due to production scheduling problems, only one experimental harvester was available for testing -- and this late in the crop. Hence, only one run was made comparing the conventionally harvested cane with cane from this harvester. An additional series of runs was conducted on the processing response vs time of cane left in the field after harvesting by the conventional method. Considerable data were collected on cane quality under simulated storage and harvesting conditions.

EQUIPMENT AND PROCEDURE

Processing. Two test procedures were followed involving (a) 100 lb samples of cane for cane quality evaluation and (b) 2 to 3 ton cane consignments for processing response. The 100 lb samples, which were processed under simulated commercial scale milling severity, provided information on the cane and juice quality but permitted no conclusions on the cane millability as ability of the mills to take the feed, mill chokes, etc. The 2 to 3 ton cane consignments permitted observation of the millability of the cane as well as the response at the subsequent clarification and crystallization stations. Obviously, the factory mill material balances and the associated analyses did provide data on cane quality as well, and these data were used as necessary to supplement cane quality observations from the smaller samples.

Cane quality evaluation: Milling of 100 lb samples was accomplished on the hydraulically loaded small Farrel mill (12 in. dia x 12 in. long rolls). For maceration, an elevated graduated cylindrical tank terminates in a sparger near the discharge roll of the mill. Commercial scale milling severity was simulated by passing the cane and subsequent bagasse through the mill for a total of 4 passes with 20% maceration on cane. Half of the water was added to the bagasse mat exiting from the first mill pass and the remaining half to the mat from the second pass. This was followed by 2 dry or dewatering passes. Cane, water, and juice were weighed and maceration water measured. Samples of juice and bagasse were procured for subsequent analyses.

Processing response: 2 to 3 ton cane consignments were milled in the factory tandem (large mill) and the extracted juice was processed on the pilot plant facilities to sugar and molasses. The milling equipment consists of 2 sets of knives and a Squire 2-roll crusher and 3 3-roll mills (18 1/2 in. dia x 24 in. long rolls). Cane, juice, and bagasse weights were determined and the maceration water was metered. The extracted juice was processed on the first floor pilot plant, which consists of 2 100-gal cone bottom tanks with mixers, shell and tube juice heaters, 5 100-gal cone bottom settling tanks, and a forced circulation evaporator. The third floor pilot vacuum pan station includes 2 calandria-type vacuum pans with 2.5 ft² heating surface, mechanical stirrers, and a strike volume of about 1.5 ft³. The pans are equipped with shell and tube condensers and vacuum pumps, conductivity meters, absolute pressure indicators, thermometer temperature indicators, and a mobility probe on one pan. A 1,400 rpm Byrd centrifugal (12 in. basket dia x 5 in. deep) completed the installation used for these tests.

Analytical Procedures. With the exception of gum, dextran, and Leuconostac determinations, routine laboratory analytical procedures were followed. Gums were determined by the alcohol precipitation method of Roberts and Friloux (5), which entails removal of starch and suspended solids by centrifuging, alcohol precipitation and centrifuging for separation of the alcohol insoluble gums,

resolution of the gum precipitate in water, addition of phenol and sulfuric acid, and colorimetric determination at 485 mμ as equivalent anhydroglucose using pure glucose solutions as a standard. Through the courtesy of Dr. James Irvine, Superintendent of the U.S. Sugarcane Laboratory at Houma, Audubon Sugar Factory personnel were able to observe the routine analytical procedure at the Houma Station.

The haze method of Nicholson and Horsely as modified by Keniry, Lee and Mahoney (2) was used for the dextran determination. This technique entails the addition of trichloroacetic acid to the juice, filtration with filter aid, addition of ethyl alcohol and the determination of the haze intensity at 720 mμ - the value being compared to that of dextran standards prepared from a culture of Leuconostoc mesenteroides.

For the Leuconostoc mesenteroides count, the sucrose agar of McCleskey, et al (4) with the azide modification of Mayeaux and Colmer (3) was used. A final concentration of 0.005% azide was obtained by the addition of 0.5 ml of a 1% sterile sodium azide solution to 100 ml of the following medium:

Bacto tryptase	10 g
Bacto-yeast extract	5 g
Sucrose	100 g
Bacto-agar	20 g
Distilled water	1,000 g

For assistance with this technique, we are indebted to Dr. Arthur Colmer, Alumni Professor of the Microbiology Department, Louisiana State University.

Cane Supply and Preparation. Through the cooperation of Dr. Mike Giamalva, Head, Outfield Sugars, Louisiana Agricultural Experiment Station, a ready supply of hand-cut, burned when necessary, and hand-loaded cane was assured for the small mill tests. Messrs. Randolph Roane and Clarence Lemaire of Jeanerette provided cane for the factory scale tests on cut-chop harvesting, while cane from Harry L. Laws & Company (Cinclare) was used in the factory scale tests on the effect of storage in the field. For the small mill studies of cut-chop cane, the cane was cut by machete into 20 in. billet lengths, the same length as that produced by the J & L harvester. While this procedure admittedly gave a sharp cut free of fraying, the quality of the cut was not too different from that observed with the chopper harvester.

Cut-Chop Harvester. For the processing response of cut-chop cane, the experimental J & L Engineering Company Model S-16 Louisiana combine cut-chop cutter, loader, cleaner harvester was used. This machine consists of the usual gathering, cutting, and topping features. Vertical circular topping type blades spaced at 20 in. intervals are located immediately after the cutting and topping provisions. An inclined rubber belt conveyor carries the chopped cane to a cross conveyor discharging to the cart. Induced draft type blowers are located at the junction of the inclined and cross conveyors and at the point of cane discharge.

Constant Temperature Cane Storage. An improvised "hot box" consisting of two 24 in. dia x 10 ft long steel cylinders capable of holding 400 lb of cane and enclosed in bagasse bales for insulation was used for the cane storage studies at elevated temperatures. The cane rested on a board running the length of the cylinders, under which were located steam distribution headers. Temperature as indicated by thermocouples was manually controlled by adjusting the steam.

QUALITY OF WHOLE-STALK CANE

As a base or reference point, it was helpful to have some feel for the relative juice quality of whole-stalk unburned cane. This phase of the study was of necessity limited and the data are abstracted from the investigations on storage, tops, and method of harvesting. For this same reason, the number of varieties represented is limited. Tabulated below is the mixed or undiluted juice quality of unburned whole-cane ground within 16 to 24 hr of cutting on the factory mill - or on the small mill under conditions simulating commercial-scale extraction severity.

Table 1. Quality of mixed juice from whole-stalk unburned cane.

Variety	Brix	Pol	Purity	Gums (mg/ml)	Dextran		Leuconostoc count per ml
					(mg/ml)	% brix	
L 60-25	15.17	13.03	85.89	0.64	0.12	0.07	4.4 x 10 ⁵
L 60-25	15.27	12.61	82.58	0.80	-	-	4.6 x 10 ⁵
CP 48-103	13.85	11.60	83.75	0.70	0.12	0.08	4.7 x 10 ⁵
L 62-96	13.38	10.90	81.15	0.32	0.15	0.11	2.9 x 10 ⁶

Other than L 62-96, the cane was hand cut top and bottom. L 62-96 was mechanically harvested and loaded, and the cane was accompanied by a considerable volume of field soil, which undoubtedly contributed to the high Leuconostoc count. The value of 0.32 mg/ml gums for this variety appears low. Otherwise there is a good agreement between these data and that appearing in the literature.

CANE QUALITY -- WHOLE-STALK, BURNED, AND CHOPPED CANE

Table 2 below shows the initial juice quality of hand cut whole-stalk, burned, and chopped cane (20 in. billet length prepared by machete) milled within 16 hr of harvesting. The variety was L 60-25. All cane was hand loaded, and no field soil accompanied the material to the factory.

Table 2. Mixed juice quality of whole-stalk, burned and chopped cane.

<u>Brix</u>	<u>Pol</u>	<u>Purity</u>	<u>Gums</u> (mg/ml)	<u>Dextran</u> (mg/ml)	<u>% brix</u>	<u>Leuconostoc</u> count per ml
<u>Whole Stalk</u>						
15.17	13.03	85.89	0.64	0.12	0.07	4.4 x 10 ⁵
<u>Burned</u>						
15.97	13.67	85.59	0.86	0.16	0.09	1.2 x 10 ⁶
<u>Chopped</u>						
15.37	13.18	85.75	0.78	0.12	0.09	1.0 x 10 ⁶

The results are typical of those observed with other samples, and there is no evidence to suggest significant deterioration within 16 to 24 hr after harvesting. Burned and chopped cane both showed higher initial gum and dextran content and Leuconostoc count than whole stalk cane. For the burned cane this would be attributable to the burn damage to the cane rind and the tissue adjacent to the rind. That the chopped cane showed no greater quality deterioration than indicated above is probably due to the rather long billets (20 in.) and the clean cut (which was subsequently closely duplicated with the mechanical harvester).

EFFECT OF TOPS ON CANE QUALITY

Early in the crop, it is common to hear the older sugar boilers complain of gummy massecuties because of high topped cane. For this reason, a brief phase of the study was devoted to the relative gum and dextran content of cane tops and of the mature stalk section. Cane was prepared by removing all foliage except for the tight green leaf roll around the top sections, since this would not be removed by burning in the field anyway. Stalks were topped above the third last formed joint from the bud as specified in the cane sampling procedure (6). Each stalk was then topped above the last mature joint and the top sections were composited. The remaining stalk sections were composited as "mature" sections. The results, using CP 48-103, are shown in Table 3. The cane was ground within 24 hr of harvesting.

Table 3. Mixed juice quality of tops and mature sections.

<u>Section</u>	<u>Brix</u>	<u>Pol</u>	<u>Purity</u>	<u>Gums</u> (mg/ml)	<u>Dextran</u> (mg/ml)	<u>% brix</u>	<u>Leuconostoc</u> count per ml
<u>11/29/72</u>							
Tops	6.80	1.40	20.59	0.98	0.45	0.64	8.0 x 10 ⁶
Mature	13.85	11.60	83.75	0.70	0.12	0.08	4.7 x 10 ⁵
<u>12/7/72</u>							
Tops	6.17	1.42	23.01	0.92	0.25	0.39	1.3 x 10 ⁷
Mature	11.69	9.60	82.12	0.78	0.11	0.09	3.9 x 10 ⁶

Particularly notable is the relatively high dextran content and Leuconostoc count in the tops vs the mature sections. Even more striking is the fact that while the top sections accounted for about 10% of the weight of the whole cane, the dextran content of the tops was 38% (11/29) and 27% (12/7) of the total dextran in cane. In other words, topping immediately above the mature joint would remove about 32% of the dextran in that part of the stalk now classified as net cane.

EFFECT OF STORAGE CONDITIONS ON CANE QUALITY

Cane deterioration has long been associated with delay between cutting and grinding. Problem areas might be defined as (a) in the field between cutting and loading, (b) at the transloading station for truck-trailer transport, and (c) in the factory yard. Such climatic conditions during storage as temperature and humidity are recognized as critical factors in the rate of deterioration.

Storage Temperatures. A few factories have reported exceedingly high yard-pile temperatures from thermocouple measurements. Unfortunately these data are not documented. During hot humid weather, reports have been received of cane piles steaming as they were liquidated after 12 to 24 hr. Attempts to get yard-pile temperatures early in the crop at a nearby factory were unsuccessful. A satisfactory run was finally achieved at Helvetia factory, but in November during a cold rainy spell. Thermocouple leads were inserted in a 20 ft high pile at 5 ft and 10 ft from the bottom of the stack. The observed temperatures are presented in Table 4.

Table 4. Yard stack temperatures.

Date	Time hr	Temperature (°F)		
		Air	5 ft	10 ft
11/16	0	54	-	-
11/16	14	44	52	55
11/17	18	42	46	48
11/17	22	46	45	48
11/18	42	53	48	47

It is clear from the above that in cold weather, factory cane-stack temperatures approximate that of the ambient air. As for temperature in the heap row during burning, Balch and Broeg (1) reported thermocouple measurements of 133 F, with evidence of melting of the wax coating suggesting temperatures as high as 172 F. The subject of heap-row and yard-pile temperatures will be investigated during the warm humid stages of the 1973 crop.

Deterioration During Storage. Attempts to store cane samples in nearby factory stacks were unsuccessful, and lacking adequate data on yard-pile temperatures, arbitrary temperatures were selected for the storage investigations. As indicated below, no particular problems were encountered in simulated yard storage conditions at what might be termed ambient temperatures. Here samples of L 60-25 were prepared, placed in burlap sacks, and located under several slings of cane in the Audubon Sugar Factory yard. Despite the rather warm air temperature, the temperature of the stored cane did not exceed the maximum ambient temperature of about 80 F. The results of this investigation are summarized in Table 5.

Table 5. Mixed juice quality of cane stored at ambient temperatures.

Time hr	Brix	Pol	Purity	Gums (mg/ml)	Dextran (mg/ml) (% brix)		Leuconostoc count per ml
<u>Burned</u>							
24	12.00	9.15	76.25	0.84	0.12	0.10	8.9 x 10 ⁵
48	14.17	10.88	76.78	0.82	0.25	0.17	1.2 x 10 ⁷
192	15.54	9.95	64.00	>2.00	0.20	0.12	7.0 x 10 ⁵
<u>Chopped</u>							
24	13.71	10.75	79.90	0.40	0.10	0.07	2.1 x 10 ⁵
48	15.71	12.61	80.30	0.66	0.13	0.08	6.7 x 10 ⁵
192	16.72	11.64	69.70	1.36	0.14	0.08	5.6 x 10 ⁶

From the results in Table 5, it appears that chopped cane exhibits better storage response at ambient temperatures than burned cane (although 0.25 mg/ml dextran for the burned cane after 48 hr appears to be on the high side, and 0.14 mg/ml for the chopped cane after 192 hr appears low). This phenomenon was observed again in a subsequent test under identical conditions. At 102 F in an improvised hot box, the keeping quality of chopped and burned cane was about the same. At elevated temperatures, the storage response was reversed, with the chopped cane showing a faster rate of deterioration than burned cane. For these studies the samples were stored in the hot box at an average temperature of 135 F. The results of these investigations are shown in Table 6.

Table 6. Mixed juice quality of cane stored at elevated temperatures.

Time <u>hr</u>	<u>Brix</u>	<u>Pol</u>	<u>Purity</u>	<u>Gums</u> <u>(mg/ml)</u>	<u>Dextran</u> <u>(mg/ml) (% Brix)</u>		<u>Leuconostoc</u> <u>count per ml</u>
<u>Burned</u>							
24	15.09	12.30	82.10	0.84	0.08	0.05	2.2×10^6
48	15.04	12.08	80.31	1.14	0.16	0.10	1.5×10^6
144	14.98	8.80	58.37	11.60	> 5.00	> 3.15	2.9×10^6
<u>Chopped</u>							
24	15.09	12.46	82.57	1.00	0.24	0.15	6.2×10^6
48	15.24	12.37	81.17	1.58	0.62	0.38	2.4×10^7
144	14.16	8.20	57.91	11.00	> 5.00	> 3.34	1.9×10^7

Storage at 135 F represents severe conditions under any circumstances. The chopped cane after 48 hr storage exhibits considerably higher gum and dextran content and *Leuconostoc* count than the burned cane. The negligible change in *Leuconostoc* count after extended storage has been observed by other investigators and apparently indicates that growth of the organism has been arrested. Nevertheless, there was a continued formation of gum and dextran.

It is clear that chopped cane does not lend itself to storage in the conventional cane stacks or piles. The above data suggest that under warm humid conditions, losses with burned cane may also be appreciable.

Response of Cane Tops to Storage. Samples of cane were stored and immediately prior to milling they were topped in the manner described in the previous section on effect of tops. The top and mature sections were milled separately. At 80 F a very moderate increase in gum and dextran content of the tops was observed after 72 hr. However, after 120 hr (5 days) the dextran content of the tops has doubled from 0.45 to 0.95 mg/ml while that of the remaining mature sections increased by only 40% (from 0.12 to 0.17 mg/ml). Unfortunately, subsequent similar studies at elevated temperatures were incomplete due to the loss of several critical juice inspections.

PROCESSING RESPONSE OF CUT-CHOP VS BURNED CANE

The preceeding cane quality tests as well as similar investigations at other research centers have established that the parameters of gums, dextran, and *Leuconostoc* count are particularly responsive to cane quality deterioration, and as such should serve as useful criteria of cane quality. While helpful, these parameters do not tell the ultimate story of sugar yield or the processing response at the individual factory stations, particularly clarification and crystallization. Because the Audubon Sugar Factory is particularly well suited to plant scale processing studies, it was the initial intent to proceed as rapidly as possible into this area of investigation. Unfortunately, equipment production scheduling difficulties delayed tests on a commercial scale combine cut-chop harvester cleaner until the latter part of December.

This phase of the studies dealt with the processing response of cane harvested by (a) the conventional machine cutting top and bottom, laying in the heap row, burning, and transferring by mechanical loader to field carts and (b) combine cut-chop harvesting in which the cane is cut top and bottom in the conventional manner, chopped into 20 in. billets, subjected to an air blast for the removal of loose foliage, and loaded into a cart accompanying the harvester.

Conventionally harvested cane was cut December 7, burned the following day, loaded, and delivered to the Audubon Sugar Factory Monday and ground on December 12. The original plan to concurrently process cut-chop cane from the same area was abandoned due to problems in the operation of the harvester, which had just been released to the field. These problems were subsequently resolved, and the cut-chop cane was procured from a nearby plantation. This cane was cut December 15, and loaded into wooden bins. The bins were delivered to the Audubon Sugar Factory Monday and the cane ground on December 19. The variety NCo 310, from the Jeanerette area, was partially lodged due to prior wind storms. The weather was wet and cold and a rather poor burn resulted with the conventional cane. Both the conventional and cut-chop harvesters operated in muddy fields. Factory mixed juice inspections from the 2 to 3 ton deliveries of each are shown in Table 7.

Table 7. Factory mixed juice quality from conventional and cut-chop harvesting.

Run	Trash (%cane)	Brix	Mixed juice		Gums (mg/ml)	Dextran		<i>Leuconostoc</i> count per ml
			Pol	Purity		(mg/ml)	(% brix)	
Convent.	11.8	13.21	10.05	76.08	1.23	0.33	0.24	3.4×10^7
Cut-chop	6.3	13.94	11.31	80.90	0.70	0.16	0.11	4.5×10^6

The trash determinations were supervised, and the trash was weighed independently as a check against the difference between the initial and final detashed sample weights. While the cut-chop cane exhibited a commendable low trash content and good keeping quality, a direct comparison of juice quality is difficult since the cane came from different growers. In lieu of this a comparison can be made of the difference in cane quality between the machine harvested cane and of hand cut whole-stalk samples from the same field and row. The hand cut samples and the machine harvested cane were ground the same day. The juice quality of the 100 lb samples is shown in Table 8.

Table 8. Juice quality from 100 lb whole-stalk unburned samples.

Run	Brix	Pol	Purity	Gums (mg/ml)	Dextran	
					(mg/ml)	(% brix)
Convent.	17.78	15.47	87.01	1.18	0.10	0.05
Cut-chop	15.24	12.73	83.53	0.86	0.12	0.07

For reasons unknown, maceration water was not added to the whole-stalk unburned sample (conventional). This accounts for the high brix and purity. Assuming a purity cut-out with water of 2.00, the difference in quality between the hand cut samples and the machine harvested cane is shown in Table 9.

Table 9. Comparison of hand cut and factory cane quality.

	Conventional			Cut-chop		
	Sample	Factory	Diff.	Sample	Factory	Diff.
Juice purity	85.01*	76.08	-8.93	83.53	80.90	-1.63
Gums (% brix)	0.62	0.88	0.26	0.53	0.48	-0.05
Dextran (% brix)	0.05	0.24	0.19	0.07	0.11	0.04
Pol (% cane)	13.49	10.04	3.45	12.82	11.26	1.56
lb/ton	270	201	69	256	225	31

*Adjusted for maceration water.

Particularly striking is the similarity in quality of the hand cut cane samples (even though procured from different fields) and the wide disparity in the factory cane quality. Also noted is the reasonably close approximation of the quality of the whole-stalk sample and the factory run cane from the cut-chop operation, and the wide quality difference between the conventionally harvested and handled material and the corresponding sample. The conventionally harvested cane shows almost a 9 point purity drop from sample to factory cane, a 5 fold increase in gums and a 25% reduction in sucrose % cane. A fairly high volume of field soil was evident in the trash sample (11.8% trash). The figure of 0.48 gums % brix for the factory cut-chop cane is undoubtedly on the low side.

Milling Response. Bagasse quality as moisture and pol was about the same for both runs. The mill feeding quality of the cut-chop cane was superior and the mill growl associated with clean cane was very evident.

Clarification Response. Clarity as measured by light transmission was better for the conventionally harvested cane (conventional 34% vs the cut-chop 20%). However, the mud volume was greater (conventional 27% vs cut-chop 17%).

Boiling Response. For the cut-chop cane, the grain, A and B strikes were completed in 6 hr. Grain was established readily and grew rapidly. No problems were encountered in drying sugar from A and B strikes. With the conventional cane, no problems were encountered in establishing the grain; however, grain growth was quite slow, and it was necessary to add a surfactant to speed up the boiling. In view of the prolonged time to complete the first strike, no second strike was boiled. Boiling problems were undoubtedly associated with the high gum and dextran content, i.e., 0.88 and 0.24% brix, respectively, although no needle grain was observed. Boiling house response for the two runs in terms of massecuite and molasses purity is shown in Table 10.

Table 10. Boiling response of conventional and cut-chop cane.

Run	Purity					
	A			B		
	Mass.	Mol.	Drop	Mass.	Mol.	Drop
Convent.	77.27	56.55	20.72	-	-	-
Cut-chop	81.92	62.59	19.33	73.05	55.23	17.82

Miscellaneous Observations. One swallow is not a harbinger of spring; nor does one run make the case for cut-chop harvesting. As originally set up, the cane was to come from the same plot. Since this was not the ultimate case, it is difficult to make a comparative evaluation of cane quality. Based on the results of the cut-chop operation alone the following preliminary observations seem to be valid:

1. Trash as leafy foliage was low and there was a complete absence of field soil, loose stubble, and extraneous tops. The trash value of 6.25% on cane as determined by the difference between the gross and net cane weights was verified by weighing the trash independently.
2. Milling performance was superior, with a complete absence of knife and mill chokes or slippage.
3. The absence of field soil in the entering cane gave a low clarifier mud volume.
4. The massecuite boiled readily, indicating no significant cane deterioration.
5. The 4-day delay between cutting and grinding did not appear to adversely affect the cut-chop cane quality; however, the weather was cold.
6. The quality of the commercially milled cut-chop cane was considerably more representative of that of the standing cane than for the conventional harvesting method. (Standing cane is a misnomer to the degree that several days elapsed between hand cutting and milling the samples. However, sample deterioration during this period was apparently minimal.)

DELAY BETWEEN CUTTING AND LOADING: EFFECT ON PROCESSING RESPONSE

The effect on cane quality of deterioration in the field after cutting has been the subject of numerous investigations, relating such parameters as time, temperature, humidity, burning, etc. with juice quality. Initially, factory scale processing response studies were planned for the months of October, November, and December to cover the range of Louisiana crop climatic conditions. Other factory research and test activity precluded attacking this specific investigation until the middle of November. When finally set up, the test program anticipated a warm spell. As things developed, the temperature ranged from a chilly 40 to 55 F throughout the tests.

A row of cane was machine harvested at Cinclare Factory on Nov 14. Two to three ton lots were mechanically loaded, delivered, and processed at the Audubon Sugar Factory on Nov 15, 17 and 20. The latter date represented an ultimate delay after harvest of 6 days. Because of rain, the cane could not be burned until after the Nov 15 run. Rain was again encountered after burning between the runs of Nov 17 and 20. The trend in factory mixed juice quality is shown in Table 11.

Table 11. The effect of field storage on factory mixed juice quality.

Milling date (Nov)	Trash % cane	Pol % cane	Mixed juice					<u>Leuconostoc</u> count per ml
			Brix	Pol	Purity	Gum	Dextran	
15	9.62	10.50	13.38	10.86	81.17	0.32	0.15	2.9×10^6
17	5.61	11.10	14.38	11.26	78.30	0.76	0.18	1.3×10^7
20	13.32	10.71	13.09	10.69	81.67	1.04	0.22	3.2×10^7

Dextran content as % brix was 0.11, 0.12, and 0.16 for the 3 successive runs, and gum content 0.23, 0.50, and 0.76. The purity for the Nov 17 run appears low since the crusher juice and syrup purities for the Nov 15 and 17 runs were almost identical. Some decrease in cane quality by the final run is evident from the tabulation below of clarified juice and syrup purity.

Milling date (Nov)	Purity	
	Clarified juice	Syrup
15	83.13	84.65
17	83.88	84.96
20	82.05	83.59

Mud volume remained below 17% (the lowest draw off on the batch clarifiers) and juice clarity remained excellent as indicated by light transmissions of 27, 35, and 33% for the successive runs.

In view of time and personnel limitations, the syrup from the middle (Nov 17) run was stored in anticipation of boiling if difficulties developed with the last run. As it turned out, in both the first and the last runs, the grain, A, and B strikes were all completed within 6 hr for each run, and the sugar purged easily. Massecuite and molasses purities for the runs are shown in Table 12.

Table 12. Boiling response of cane stored in the field.

Milling date (Nov)	Purity					
	A			B		
	Mass.	Mol.	Drop	Mass.	Mol.	Drop
15	84.57	66.70	17.87	74.32	58.16	16.16
17	-	-	-	-	-	-
20	83.27	62.53	20.74	74.42	56.42	18.00

Under the chilly conditions prevailing at the time of this test, a delay of up to 6 days in the field between cutting and processing produced no discernable effects on the processing response in the factory. Both clarification and boiling proceeded readily throughout the test. The drop in clarified juice and syrup purity between the second and the final runs would have accounted for a calculated yield loss of at least 1 to 2 lb of sugar per ton of cane.

GUMS AND DEXTRAN AS CRITERIA OF CANE PROCESSING RESPONSE

During the latter part of October, considerable difficulty was encountered in processing a series of three special test runs not related to these investigations. The cane was handled in the usual manner for such tests, being mechanically harvested Thursday, delivered to the Audubon Sugar Factory and stored in the yard for milling the following week. In common with other such investigations, the most rigorous conditions were achieved in that the cane was not burned and thus was delivered to the factory with all the attendant foliage. Under such conditions, no problems were encountered with preceeding and subsequent

tests of such a nature. In this particular test series, a very cloudy clarified juice was observed with a high mud volume and difficulty was encountered in boiling, with a slowly developing grain and subsequent slow grain growth. Gum and dextran determinations are not commonly made as part of such investigations, and during the latter part of the crop, time permitted retrieving the juice samples from the walk-in freezer and making analyses. The results of these analyses are presented in Table 13.

Table 13. Mixed juice quality from poorly processing pilot plant runs.

Milling date	Brix	Pol	Purity	Gums		Dextran	
				(mg/ml)	(% brix)	(mg/ml)	(% brix)
Oct 30	12.87	10.82	84.17	1.48	1.09	0.38	0.28
Nov 1	12.66	10.36	81.83	1.24	0.93	0.37	0.28
Nov 2	12.70	10.44	82.80	1.32	0.99	0.32	0.25

A high level of gums and a particularly high level of dextran are evident from the above tabulation. Based on information now available, processing problems would be expected at such levels. Because of the similarity in preparation and handling of the cane consignments and the fact that similar problems were not encountered in other such runs, reasons are not immediately evident for the high gum and dextran content with subsequent processing problems in this particular test series.

Another set of samples was retrieved from the freezer reflecting runs during which no processing problems were encountered other than a rather high mud volume due to the adhering trash on the cane samples. Results from the mixed juice data are summarized in Table 14.

Table 14. Mixed juice quality from trouble-free pilot plant runs.

Milling date	Brix	Pol	Purity	Gums		Dextran	
				(mg/ml)	(% brix)	(mg/ml)	(% brix)
Dec 4	12.62	10.04	79.56	0.85	0.64	0.18	0.13
Dec 6	12.96	10.02	77.31	1.10	0.81	0.24	0.18
Dec 7	12.25	9.30	75.92	1.14	0.89	0.21	0.16

The juice analyses are those of the original samples before freezing. The decrease in purity from the first to the last run may be apparent rather than real due to problems with suspended solids in the brix cylinder. The syrup samples from all runs averaged 81.00 to 82.00. A significantly lower gum and dextran content % brix is noted compared to the previous data for the refractory runs. There is a possibility that some deterioration occurred in the freezer storage, and juice storage response in terms of gums and dextran should be the subject of a special investigation.

CONCLUSIONS

These investigations are only the initial phases of a continuing program. With this in mind, the following conclusions are tentative and subject to more studies in depth.

In general, an increase in reducing sugars, gum, dextran, and micro-organism count and a decrease in juice purity are associated with increasing storage time of whole-stalk cane (burned and unburned) and unburned chopped cane.

At ambient temperatures, cane cleanly cut into 20 in. billet lengths exhibited better storage response than burned cane. To the contrary, at elevated temperatures, the storage response was reversed with the chopped cane showing a faster rate of deterioration.

With cane harvested, burned, and heaprowed in the conventional manner, no significant change in processing response was observed over a period of 6 days and at temperatures of 40 to 55 F. During this period, three runs were made in which the cane was processed to sugar and molasses.

In a series of tests, even though the top sections accounted for only about 10% of the total weight of the cane, the dextran and gum content of the top sections accounted for 18 to 43% of the total content. This clearly indicates the necessity for proper topping in the field.

Based on the one cut-chop run in December on NCo 310, the following preliminary observations seem to be valid:

1. There was essentially a complete absence of field soil, loose stubble, and extraneous tops.
2. Milling performance was superior with no knife and mill chokes and slippage.
3. Clarifier mud volume was quite low and clarified juice clarity good.

4. The massecuite boiled readily, massecuite to molasses purity drop was excellent, and the grain was uniform.
5. The 4-day delay between cutting and grinding did not adversely affect the cut-chop cane quality; however, the weather was cold.

A comparison of available data on cane quality and processing response shows that the parameters of gum, dextran, and Leuconostoc mesenteroides count are reliable indicators of cane quality as might be reflected in subsequent processing. Based on the rather limited cane quality-processing response data available, the following threshold values are suggested.

<u>Processing Response</u>	<u>Gums % brix</u>	<u>Dextran % brix</u>
Poor	0.90	0.25
Fair	0.77 to 0.89	0.11 to 0.24
Good	0.76	0.10

Some cane with high purity and low reducing sugar ratio was marked by high gum and dextran content and processed poorly. This was apparently stale cane with an initially high purity and low reducing sugar ratio. To the contrary, cane with lower purity and higher reducing sugar ratio, but with low gum and dextran values, processed well. Such would be expected of immature but fresh cane.

Both the dextran and gum analyses gave a good indication of the cane quality and in the processing response of the juices. While the dextran analysis is less time consuming (1/2 hr) than the gum analysis (2 hr), it presents the problem of a standard curve. Different curves have been reported in the literature and all seem to differ because of the molecular weight of the dextran standard.

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CORROSION-RESISTANT CONCRETES AND
MORTARS FOR THE SUGAR INDUSTRY

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OPERATION OF AN ANTI-FOULING EVAPORATION PROCESS PILOT PLANT
AT THE
RACELAND FACTORY OF THE SOUTH COAST CORPORATION

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ABSTRACT

During the 1972-73 Louisiana grinding season, Quality Boiler and Machine Works, Inc, with the help and cooperation of the South Coast Corp, ran a series of tests on an anti-fouling evaporation process to determine the validity of the principles involved in the process. The pilot plant was operated from Oct 21, 1972 until Jan 5, 1973, both as a 2nd body and as a 4th body, for a total actual operating time of more than 1100 hr. The unit was not cleaned or "boiled out" in any way during the entire operation, except for water used to flush sugar made in the unit while operated as a 4th body, and it operated very well during the entire test period. The unit was run for more than 800 hr as a 2nd body before it was placed into operation as a 4th body. The unit was run for more than 300 hr as a 4th body following the initial series of tests, since everyone concerned with or interested in the project wanted to know how well this system would work as a 4th body. The results of tests at the Raceland factory have been carefully analyzed, and we have designed a full size unit based on our findings.

INTRODUCTION

The formation of scale in the evaporators of most raw cane sugar factories is a serious problem since it probably requires more time to remove this scale from the evaporators than to do any other regular maintenance work during the grinding operations. This report is about a type of evaporation process which will minimize the problem of scale formation in the Louisiana sugar industry.

The report has been divided into 3 major parts:

- I. Equipment description
- II. Operation as a 2nd body
- III. Operation as a 4th body

The equipment description will be accompanied by a selection of slides of the pilot plant at Raceland.

I. EQUIPMENT DESCRIPTION

The equipment used in the tests consisted of 3 units; 1) the heat exchanger, 2) the pumping system, and 3) the flash body. The heat exchanger was designed to simulate conditions in a full size unit and was fitted with stainless steel tubes. The total effective heating area in the exchanger was 78.4 sq ft. The pumping unit was a centrifugal type, driven by an electric motor. It was rated at 60 gpm with a head of 280 ft. The flash body was designed to simulate conditions in a full size unit, except that there was no provision made for removing entrainment from the vapors.

II. OPERATION OF THE PROCESS AS A 2ND BODY

All connections to the test unit were made in parallel with the full size system so that our pilot plant conditions would be identical to those in the full size evaporator.

Several problems resulted from our original 2nd body arrangement. Our most serious problem was that we could not obtain design capacity of the pump, due to flash occurring at the pump suction. After approximately one week, we were able to overcome this problem completely.

The only other serious problem we experienced while operating the unit as a 2nd body was that we had a difficult time getting a true reading of condensate flow out of the heat exchanger (based on a comparison of apparent overall heat transfer coefficients and observed flow of condensate).

We have reached the following conclusions from our testing of the process as a 2nd body during a 42-day operation period.

- A. The process should run for an entire grinding season as a 2nd body without having to "boiled out."

B. The apparent overall coefficient of heat transfer values ranged from 600 to over 1600 BTU/sq ft/°F/hr.

C. The apparent evaporation rates ranged from 8 to 14 lb/hr/sq ft.

D. The capacity of this system as a 2nd body does not appear to be considerably greater than that of a well designed conventional system, although it does have a better potential capacity than we observed based on the apparent overall coefficients.

All connections to the test unit (except for the condensate line) were made in parallel with the full size system so that our pilot plant conditions were identical to those in the full size evaporator.

III. OPERATION AS A 4TH BODY

Our most serious problem with the 4th body installation was that we had difficulty in removing condensate from the heat exchanger. We actually tried about 5 different arrangements for removing the condensate, including the installation of a gear type pump in the line, but none of our arrangements were satisfactory, and the only times that our final connection (into the bottom of the 4th body) allowed us to get capacity information on the installation were when the large set of evaporators became fouled and the increase in pressure drop allowed the condensate to flow through the meter. We made sugar at least 3 times in the pilot plant during the test period, and this was also a problem, since we did have to partially disassemble the unit once and use water to melt the sugar. This problem was due to a wide variation in feed and other operating conditions in the large evaporator; however, it should not occur in a full size process unit.

We have reached the following conclusions from our testing of the process as a 4th body during a 23-day operating period:

A. The process should run several times longer than a conventional evaporator, and possibly for an entire grinding season as a 4th body without being "boiled out."

B. The apparent overall coefficients of heat transfer values ranged from 320 to 380 BTU/sq ft/°F/hr.

C. The apparent evaporation rates ranged from 10 to 18 lb/hr/sq ft.

D. The capacity of this system as a 4th body does appear to be considerably greater than that of a conventional system, and the apparent overall coefficients of heat transfer and evaporation rates both indicate this to be true.

Since we are aware that there may be a great number of questions concerning this development, we will devote the remainder of time allowed for answering a few of these questions.

CORE SAMPLING OF LOUISIANA SUGARCANE - 1972 STUDIES

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ABSTRACT

Cane payment in Louisiana is based on a sampling system which still retains the concept of crusher juice quality (a holdover from the days of hand-harvested cane) with modifications for trash content and juice purity (to accommodate mechanical harvesting). With the current intensive field mechanization, and particularly under wet muddy field conditions, the present sampling system does not adequately reward premium quality cane nor penalize substandard material. In view of the limitations of the current system, studies at the Audubon Sugar Factory have continued with the goal of evolving a cane evaluation system which would: a) remove the judgement factor in selection and processing the sample, b) standardize the sample procurement and processing equipment, c) minimize personnel requirements, d) divorce the system from mill operations, 3) provide a sample representative of the quality of the material in the cane consignment, f) reflect the effect of trash in general and field soil in particular on juice quality and quantity, g) provide a measure of cane quality in terms of the estimated recoverable sugar in the cane, and h) for the processor, contribute to the factory chemical control and for the grower, provide a means for evaluating varietal selection and cultural practices. With the availability of commercial-scale core-samplers, sample disintegrators, and a vertical hydraulic press capable of exerting mill-scale pressures on a large sample, sampling studies initiated in 1953 were reactivated. The initial scope of the current investigations entails comparison of the quality of a cane consignment as determined by milling in the factory with that predicted by the conventional and by the core sampling technique. The core sampling system used in these studies proved simple, practicable, and meets many of the goals cited previously. Core sampling is superior to the conventional system as a sensor of juice quality due to the more representative nature of the sample procured by coring. While there is a variability among core samples from the same consignment, there is no bias relative to the location of the sample in the load. Processing the core sample in a 3-roll mill does not adequately reflect trash in the consignment when it includes a large volume of field soil. Such material washes out into the juice and does not appear in the sample bagasse as fiber or dry solids % cane. Preliminary tests with the vertical hydraulic press (which arrived too late to be incorporated into the complete test series) indicate that the press is a good sensor of juice quantity in that the press residue or bagasse retains much of the field soil in the sample. These studies should be continued in 1973 with the substitution of a hydraulic press for the sample mill as a sample processing device.

INTRODUCTION

General. Improved varieties and cultural practices in Louisiana have resulted in a significant improvement in the quality of the standing cane prior to harvest in terms of yield per acre and per ton of cane, disease, insect, and freeze resistance, and many other desirable features. Unfortunately, the increasing intensity of field mechanization in the form of larger and more powerful equipment, large farm units with the subsequent problems of harvest monitoring and discipline, and adverse climatic conditions of the past 3 crops have contributed to a marked increase in the volume of field soil, foliage, loose tops, and stubble, and of mangled cane accompanying the cane consignments to the factory.

Adequate evaluation of cane for payment with the current sampling system is particularly difficult under such conditions. As a result, the grower delivering superior quality cane is not being adequately rewarded, and by the same token substandard cane is not properly penalized. We appear to have arrived at the point where there is little incentive for harvest control and discipline, and as a result the entire industry suffers.

The Current Sampling System. The Louisiana system of cane sampling and testing for cane payment retains the concept of normal (undiluted) juice quality as a basis for cane evaluation and standard tons as the criterion of cane quality upon which payment is based. The factory normal juice brix is calculated from the crusher juice brix, and the factory normal juice sucrose (pol) is determined from the identity that the dilute or mixed juice purity equals normal juice purity. As originally implemented in the days of hand-cut cane, a grower's standard tons were calculated from his delivered tons, his crusher juice pol, the crusher juice sucrose factor (which related the factory normal to crusher juice sucrose or pol), and tables for converting the grower's normal juice sucrose to standard per delivered ton.

With the advent of mechanical harvesting, the practice of washing cane on the feeder table, and the return of cush-cush prior to the crusher, the system has been modified to provide for the removal of cane samples from the feeder table or vehicle, trash samples, and the inclusion of a juice purity factor (to account for the extraneous material accompanying the cane), and sucrose samples to be ground in a sample mill (to eliminate the dilution effect on crusher juice of the cane wash water and cush-cush). Incorporating a sample mill into the system has necessitated additional factors. One is the dilution compensation factor, which relates the sample mill juice brix to that of the undiluted crusher juice. This is determined periodically without any wash water or cush-cush prior to the crusher. With this factor it is

possible to calculate a daily undiluted crusher juice brix and from this the conventional factory normal juice brix. Additional factors are the sample mill brix and sucrose factors which relate the factory normal juice brix and sucrose to that of the sample mill. From these factors, the grower's gross cane delivery, his trash and sample mill inspections, and tables for converting his normal juice sucrose and purity to standard per net tons, it is possible to determine the grower's standard tons and subsequent cane payment.

An Idealized Cane Sampling System. Among other things, an idealized cane sampling system for payment should:

1. Provide a sample representative of the quality of the cane in the consignment.
2. Remove the judgement factor in selecting and processing the sample.
3. Standardize the sample procurement and processing equipment and procedure.
4. Minimize sampling and processing personnel requirements.
5. Reflect the quantity of juice in the cane as well as quality.
6. Express cane quality in terms of recoverable sugar in the cane consignment - a criterion meaningful to both the factory and the grower - and minimize the number of factors necessary to determine the cane quality.
7. Separate the sampling system from the mill operation.
8. Supplement chemical control data for the factory and provide meaningful data for the grower relative to his varietal selection and cultural practices.

Previous Audubon Sugar Factory Sampling Studies. Early Audubon Sugar Factory cane sampling studies were devoted to problems of trash sampling and mechanical grab design. The problem of securing a representative cane sample and the need for complete cane analysis to include juice quantity as well as quality were recognized early, and led in 1953-58 to a cooperative industry, USDA, and Audubon Sugar Factory program for the design, construction, and operation of a core sampling device (3).

These studies were subsequently discontinued due to the wide variation in cane quality throughout the length of the stalk (a condition common to Louisiana with its short growing season), the prevailing method of handling cane in slings, the localized nature of the core sample (the coring tube traveled solely in a vertical axis), and the time-consuming, wet-disintegrator sample analysis technique. It is interesting to note that core sampling was subsequently adopted in Hawaii and more recently in Puerto Rico and is supplemented by the wet disintegrator analysis.

Evaluating juice quantity in a cane sample was investigated again in 1959-61, where cane samples by mechanical grab were processed in a) the hydraulically loaded Farrel mill, b) the French screw press, and c) a locally fabricated vertical hydraulic press (7). Good reproducibility was achieved with the mill and French press. However, this approach was discarded due to the large sample size required and problems involved in standardizing the extraction equipment and procedure.

The operating procedure and analytical technique with the vertical press were quite simple; however, reproducibility was poor due to problems of sample disintegration and inadequate pressure for the 8 in. diameter press piston and cylinder.

Current Studies. The current studies were initiated in 1972 in view of the availability of commercial core samplers of varying design, sample disintegration equipment, a hydraulic press capable of exerting mill pressures on a large piston diameter, and the application of core sampling for cane payment in other cane-growing areas (2, 5, 6). The success of the current studies obviously depends on the ability to adapt core sampling to conditions unique to Louisiana, such as immature cane with a relatively large portion of immature top sections and the high volume of extraneous material accompanying the cane to the factory.

EQUIPMENT AND PROCEDURE

The Farrel Sample Mill. All core samples and the conventional sucrose samples were processed on the hydraulically loaded 3-roll (12 in. dia. x 12 in. long rolls) Farrel sample mill.

The Audubon Sugar Factory Mill. After sampling, the cane consignments were processed in the Audubon Sugar Factory Squier mill, which consists of 2 sets of knives, a 2-roll crusher and 3-roll mills (18 1/2 in. dia. x 24 in. long rolls).

The Vertical Hydraulic Press. Because of its late arrival, only a few screening runs were made on the Pinette-Emidecau Type OB102 hydraulic press. This press has a 5 11/16 in. dia. x 6 1/8 in. long perforated cylinder and a piston capable of exerting a maximum pressure of 3600 psig. (Because of the limited number of runs no press data are included in this paper; however, it will be used in place of the Farrel mill for sample processing in the 1973 studies).

The Core Sampler. Cane in the field carts was sampled by means of a J & L Model X-2 core sampler equipped with a Reitz Model PB10 prebreaker for sample preparation. The X-2 core sampler is an electro-pneumatically operated device with an 8 in. dia. coring tube which enters the cane delivery from top to bottom with an inclination of 45° to the vertical plane. This equipment is located at the Cinclare factory.

Miscellaneous Equipment. For removal of trash samples from the cane on the feeder table, a hydraulically operated mechanical grab was used. Transfer of the cane consignment and core samples from Cinclare to the Audubon Sugar Factory was accomplished by means of a 2 1/2 ton truck.

Cane Supply. Mechanically cut and loaded cane was procured from the Cinclare factory cane fields. It was transferred to the coring station by tractor-drawn field carts in 2-to 3-ton slinged bundles.

Cane Sample Procurement. As finally evolved, the cane sampling procedure entailed removing 3 core samples, one each from the back, middle, and front of the bundle, with the front being the end toward the tractor. The individual samples, weighing about 30 lb each, were placed in plastic bags and transferred to the truck for delivery to the Audubon Sugar Factory along with the cored cane consignment.

Core Sample and Cane Consignment Transfer. After coring, the bundle was transferred to a truck and delivered to the Audubon Sugar Factory along with the individual core samples.

Sample Removal at the Audubon Sugar Factory. After breaking the bundle on the feeder table, one trash sample of about 100 lb was removed by mechanical grab, and 3 hand-grab sucrose samples were removed from different locations in the cane mat. Each sample weighed about 30 lb.

Processing the Core Samples. Each core sample was removed from its plastic bag and passed 4 times through the Farrel mill. Cane, juice, and bagasse weights were determined, and juice and bagasse samples were removed for analysis.

Processing the Trash and Sucrose Samples. The trash samples were processed in the conventional manner for determining trash % cane. Each sucrose sample was passed once through the Farrel mill and a juice sample removed for analysis.

Processing the Sampled Cane Consignment. After removal of the samples, the cane was processed in the factory milling tandem with the addition of 20% maceration water and a last mill roll speed of 30 fpm. During milling, samples of crusher and last roll juice and bagasse were removed and composited. Following the run, bagasse and juice weights and maceration water were determined. Samples of mixed juice were removed from the weighing tank, and the crusher, mixed, and last roll juice, and the bagasse samples were transferred to the laboratory for analysis.

Analyses. Juice analyses included brix by hydrometer and pol by the Horne dry lead method. Bagasse was analyzed for moisture with the Dietert Model 278A Moisture Teller. Pol in bagasse was determined by the wet disintegrator method in which 100 g of bagasse were mixed with 1000 g of water (to which 0.25 g of Na_2CO_3 had been added) and disintegrated in a 1-gal Waring blender. The juice extract after 10 min of blending was then analyzed for pol by the conventional method. Brix in bagasse was calculated from the pol and the mill juice purity (last roll juice for the factory mill and extracted juice purity for the Farrel mill). Fiber was by the indirect method, i.e., $100.000 - (\text{Moisture} + \text{Brix})$.

AREAS OF INVESTIGATION

Correlation of Sample with Factory Mill Data. Core and conventional sucrose sample juice quality as brix and pol was compared with that of the factory crusher juice. Juice quantity was compared by way of correlations of the core and factory bagasse % cane.

Variability Among Core Samples from the Same Vehicle. The variation in cane quality and related parameters was investigated by way of correlations among the 3-replicate core samples from the same vehicle. Additionally, correlations were developed to indicate any bias as a function of the location of the core sample.

Application of the Core Sample System to a Cane Evaluation Scheme. A theoretically recoverable-sugar formula was developed based on the core sample data and assumed extraction and boiling house performance. The resultant cane quality was expressed as lb 96° sugar per ton of cane. The theoretically recoverable sugar from the core samples was compared with the predicted sugar yield from the factory mill data. This comparison took the form of a liquidation factor which related the sum of the predicted sugar yields from all the mill runs with that from the core samples. By means of the liquidation factor, a corrected recoverable sugar was determined for the core data from each run. In practice, such a corrected sugar recovery would be used as a basis for cane payment.

Observations on the Conventional Sampling System. For those runs in which 3-replicate sucrose samples were taken from cane on the feeder table, the variability in juice brix and pol among the samples was analyzed and compared to that with the 3 core samples. These data were incorporated into sample mill brix and sucrose factors to see which system gave the most consistent factors.

Reproducibility and Accuracy of the Trash Sample. Since the conventional trash determination is in effect an indication of juice quantity (in the absence of any fiber determinations), some observations were made on the accuracy and reliability of the conventional trash sampling system.

Correlation of Cane Quality by the Current Sampling System with That of the Factory. A correlation was derived relating cane quality from the conventional sampling scheme in terms of commercially recoverable sugar with that predicted from the corresponding factory run.

RESULTS

Correlation of Sample With Factory Data. The factory mill analyses are shown in the Appendix, Table A-1. For each run, the average of the analyses of the replicate core samples was compared with the corresponding cane quality parameter from the mill. The following correlations compare factory and core sample juice quality and quantity. Sample juice quality is compared with that of the factory crusher rather than mixed juice, since the latter reflects dilution due to maceration. The correlation is in terms of a brix factor relating the factory to the sample data as factory/sample. Table 1 shows the correlation between factory crusher and core sample brix. For comparison, the brix from the average of the 30-lb sucrose samples from each of the consignments is also shown. The statistical correlation of the data is in terms of the standard deviation, (S.D.) and the coefficient of variation (C.V.). The latter is the standard deviation divided by the average value for the samples and expresses the standard deviation as a percent of the average value.

Table 1. Correlation of juice quality as brix; crusher vs core and the conventional sucrose sample.

Run	Date	Accumulated rain (in.)	Crusher brix	Sample*			
				Core		Sucrose	
				Brix	Factor	Brix	Factor
1	10/18	0	19.12	17.75	1.0772	19.24	0.9938
2	10/20	0	18.56	16.97	1.0937	-	-
3	10/27	2.77	18.74	18.53	1.0113	18.79	0.9937
4	11/ 3	3.63	19.82	18.81	1.0537	20.41	0.9709
5	11/ 7	3.83	16.94	16.35	1.0361	16.96	0.9986
6	11/ 9	3.83	16.96	15.42	1.0991	17.19	0.9868
11	11/30	9.24	16.28	15.56	1.0463	17.59	0.9257
12	12/ 5	10.58	14.56	14.06	1.0356	16.26	0.8954
13	12/14	13.35	14.08	13.46	1.461	16.45	0.8559
Average					1.0555		0.9526
Standard deviation					0.0290		0.0539
Coefficient of variation					2.75		5.66

* All sample data are the average of 3 samples except Run 1 (one sample), Run 2 (one core sample and no sucrose sample), and Run 5 (2 core samples).

The brix factor (crusher juice brix/sample mill juice brix) is in effect the dilution compensation factor (DCF). For factories which wash their cane - resulting in a dilution of the crusher juice - the DCF is a means of calculating an undiluted crusher juice brix from the corresponding 24-hr average sample mill brix.

Numerous questions have been raised as to the reproducibility of this factor. From the above data, the core sample factor shows only 1/2 the variability of the factor as currently determined from the sucrose sample, i.e., a coefficient of variation of 2.75 vs 5.66.

Table 2 shows the correlation between the crusher juice pol and that of the core and the sucrose sample in terms of a pol factor relating the crusher to the sample data. These data indicate greater variability in pol than brix. Again, though, the coefficient of variation for the core sample is less than for the sucrose sample.

Table 2. Correlation of juice quality as pol: crusher vs core and the conventional sucrose sample.

Run	Date	Accumulated rain (in.)	Crusher pol	Sample*			
				Core		Sucrose	
				Pol	Factor	Pol	Factor
1	10/18	0	16.02	14.38	1.1140	16.38	0.9780
2	10/20	0	13.79	11.68	1.1807	-	-
3	10/27	2.77	16.12	15.40	1.0468	16.26	0.9914
4	1 / 3	3.63	17.07	15.83	1.0783	18.24	0.9359
5	11/ 7	3.83	13.72	13.09	1.0481	13.97	0.9821
6	11/ 9	3.83	13.30	11.35	1.1718	14.18	0.9379
11	11/30	9.24	13.87	13.13	1.0564	15.40	0.9006
12	12/ 5	10.58	11.47	10.17	1.1278	13.75	0.8342
13	12/14	13.35	11.55	10.00	1.1550	14.05	0.8221
Average				1.1088		0.9228	
Standard deviation				0.0535		0.0656	
Coefficient of variation				4.82		7.11	

* Sample frequency the same as in Table 1.

Tables 1 and 2 indicate that the core sampler is a better sensor of juice quality than the current sucrose sample. This would partly be explained by the presence of trash in the core sample, which also enters the crusher but is present to a much less degree in the sucrose sample.

Correlation of the juice quantity in the cane is shown in Table 3 as a bagasse factor relating the factory to the core sample bagasse % cane.

Table 3. Correlation of juice quantity as bagasse % cane: factory vs core.

Run	Date	Accumulated rain (in.)	Trash % cane	Bagasse % cane		
				Factory	Core	Factor
1	10/18	0	12.62	34.14	43.19	0.790
2	10/20	0	40.86	47.85	59.53	0.804
3	10/27	2.77	11.46	34.22	33.79	1.013
4	11/ 3	3.63	4.00	31.29	32.41	0.965
5	11/ 7	3.83	12.00	32.30	36.93	0.875
6	11/ 9	3.83	6.00	31.89	32.74	0.974
11	11/30	9.24	14.00	29.21	30.91	0.945
12	12/ 5	10.58	5.50	26.27	37.63	0.698
13	12/14	13.35	19.23	31.35	30.46	1.029
Average			13.96	33.17	37.51	0.8992
Standard deviation						0.1139
Coefficient of variation						12.67

The coefficient of variation of 12.67% compares with 2.75% (brix) and 4.82% (pol). Juice quantity is thus more difficult to predict accurately than quality. This would appear to reflect the volume of field soil in the samples. 1972 was a rainy season and numerous core samples were observed to be loaded with field soil. In the factory runs, with maceration, much of this soil washed into the juice and did not appear in the bagasse. This was also a problem with the core samples on the Farrel mill, though to a lesser extent due to the absence of maceration water.

Due to the late arrival of the hydraulic press, only a limited number of samples were processed in this equipment. These limited data showed a considerably greater field soil retention in the pressed bagasse (residue) than in the Farrel mill sample bagasse. The press thus appears to be a better trash sensor than the small mill. This will be investigated further in the 1973 studies.

Variability Among Core Samples From the Same Vehicle. As noted previously, the core samples were removed from the back, middle, and front of the bundle on most runs and processed separately in the Farrel mill. While the loading of the current 5-to 9-ton chain-net field carts and larger truck-trailers is reasonably random, such is not the case with the 2- to 3-ton slinged bundles used in these investigations because of the method of transferring the cane from the heap row to the cart. This was recognized as a

problem, and it was hoped that the diagonal corer would give a more representative sample of the whole consignment than a simple horizontal or vertical coring device. It was the intent of the replicate sample tests to indicate the variability among samples and any bias as a function of the location of the sample.

The back sample was withdrawn from the rear end of the bundle; the middle from the bundle center; and the front from the end of the bundle toward the tractor. Table 4 shows several key cane quality parameters for 7 runs, along with their standard deviations (S.D.) and coefficients of variation (C.V.).

Table 4. Variability of key cane quality parameters among core samples from the same consignment.

<u>Run</u>	<u>Back</u>	<u>Middle</u>	<u>Front</u>	<u>Average</u>	<u>S.D.</u>	<u>C.V.</u>
<u>Pol % juice</u>						
3	15.12	15.18	15.91	15.40	0.4398	2.86
4	16.63	15.06	15.79	15.83	0.7856	4.96
6	11.79	11.21	11.00	11.33	0.4092	3.61
10	13.10	13.81	13.96	13.62	0.4594	3.37
11	12.74	13.08	13.56	13.13	0.4120	3.14
12	10.49	10.54	9.47	10.17	0.6038	5.94
13	10.46	9.99	9.55	10.00	0.4551	4.55
Average	12.90	12.63	12.75	12.78	0.5093	4.06
<u>Brix % juice</u>						
3	18.14	18.28	19.18	18.53	0.5644	3.05
4	19.90	18.22	18.32	18.81	0.9424	5.01
6	15.59	15.59	15.09	15.42	0.2887	1.87
10	15.50	16.40	16.50	16.13	0.5508	3.41
11	15.12	15.58	15.98	15.56	0.4303	2.77
12	14.00	14.66	13.52	14.06	0.5724	4.07
13	13.79	13.37	13.22	13.46	0.2955	2.20
Average	16.01	16.01	15.97	16.00	0.5206	3.20
<u>Bagasse % cane</u>						
3	33.16	34.29	33.92	33.79	0.5761	1.70
4	33.33	32.43	31.46	32.41	0.9352	2.89
6	33.55	34.15	30.53	32.74	1.9401	5.93
10	35.25	34.49	35.75	35.13	0.6879	1.96
11	32.44	30.79	29.49	30.91	1.4785	4.78
12	38.95	32.28	41.67	37.63	4.8315	12.84
13	31.16	29.21	31.01	30.46	1.0851	3.56
Average	33.98	32.50	33.40	33.30	1.6478	4.81
<u>Moisture % bagasse</u>						
3	48.80	46.50	49.70	48.33	1.6503	3.41
4	47.80	44.40	48.40	44.87	2.1572	4.60
6	47.90	49.20	48.00	48.37	0.7234	1.50
10	48.90	51.50	52.00	50.80	1.6643	3.28
11	38.90	36.00	40.90	38.60	2.4637	6.38
12	49.60	51.60	47.50	49.57	2.0502	4.14
13	47.00	47.60	42.30	45.63	2.9023	6.36
Average	46.99	46.69	46.97	46.60	1.9445	4.24

Table 4. (Continued)

<u>Run</u>	<u>Back</u>	<u>Middle</u>	<u>Front</u>	<u>Average</u>	<u>S.D.</u>	<u>C.V.</u>
<u>Pol % bagasse</u>						
3	7.03	7.03	7.72	7.26	0.3984	5.49
4	8.54	6.76	6.22	7.17	1.2140	16.92
6	4.96	5.37	4.82	5.05	0.2858	5.66
10	6.06	7.44	7.58	7.03	0.8401	11.96
11	4.13	4.96	4.13	4.41	0.4792	10.87
12	5.51	5.65	5.24	5.47	0.2084	3.81
13	5.65	4.82	4.82	5.10	0.4792	9.40
Average	5.98	6.00	5.79	5.93	0.5579	9.16
<u>Pol % cane</u>						
3	12.57	12.39	13.13	12.70	0.3859	3.04
4	13.93	12.37	12.78	13.03	0.8087	6.21
6	9.50	9.26	9.11	9.29	0.1967	2.12
10	10.62	11.62	11.68	11.31	0.5954	5.27
11	9.95	10.58	10.78	10.44	0.4332	4.15
12	8.55	8.96	7.70	8.40	0.6427	7.65
13	8.70	8.28	7.83	8.27	0.4351	5.26
Average	10.55	10.49	10.43	10.49	0.4997	4.81
<u>Brix % cane</u>						
3	14.92	14.92	15.83	15.22	0.5254	3.45
4	16.67	14.96	14.83	15.49	1.0269	6.63
6	12.56	12.80	12.50	12.62	0.1587	1.26
10	12.56	13.80	13.80	13.39	0.7159	5.35
11	11.81	12.60	12.70	12.37	0.4875	3.94
12	11.41	12.46	11.00	11.62	0.7530	6.48
13	11.47	11.08	11.09	11.21	0.2223	1.98
Average	13.06	13.23	13.11	13.13	0.5557	4.16
<u>Fiber % cane</u>						
3	14.18	15.44	13.90	14.51	0.8203	5.65
4	13.99	15.39	15.85	15.08	0.9688	6.43
6	15.28	14.81	13.86	14.65	0.7234	4.94
10	15.49	13.64	13.96	14.36	0.9888	6.88
11	18.23	17.89	15.99	17.37	1.2071	6.95
12	16.76	13.09	18.76	16.20	2.8757	17.75
13	14.54	13.69	16.18	14.80	1.2657	8.55
Average	15.50	14.85	15.50	15.28	1.2643	8.16

Table 5 summarizes the data in Table 4 in terms of the average or mean value of the individual cane quality parameters and the corresponding standard deviation and coefficient of variation.

Table 5. Summary of the standard deviation and coefficient of variation of the key cane quality parameters for 3 core samples in the same consignment.

Cane quality parameter	Average	S.D.	C.V.
Pol % juice	12.78	0.5093	4.06
Brix % juice	16.00	0.5206	3.20
Bagasse % cane	33.30	1.6478	4.81
Moisture % bagasse	46.60	1.9445	4.24
Pol % bagasse	5.93	0.5579	9.16
Pol % cane	10.49	0.4997	4.81
Brix % cane	13.13	0.5557	4.16
Fiber % cane	15.28	1.2643	8.16

From the above it is clear that the variability of all cane quality factors with the exception of fiber % cane and pol % bagasse is of about the same order of magnitude, the coefficients of variation falling within the range of 3.20 to 4.81%. The data scatter for Run 12 (Table 4) was generally greater than the other runs. Eliminating this run would give a smaller magnitude for the coefficients.

A statistical analysis of the average cane quality parameters for all runs for each sample location (back, middle, and front) should indicate an inherent bias in the sample location. Such an analysis is shown in Table 6, where the all-run average is derived from the sum of the all-run front, middle, and back data.

Table 6. Significance of location of the core sample.

Cane quality parameter	Average	S.D.	C.V.
Pol % juice	12.76	0.1353	1.06
Brix % juice	16.00	0.0231	0.14
Bagasse % cane	33.29	0.7457	2.24
Moisture % bagasse	46.88	0.1677	0.36
Pol % bagasse	5.92	0.1159	1.96
Pol % cane	10.49	0.0600	0.57
Brix % cane	13.13	0.0874	0.67
Fiber % cane	15.28	0.3753	2.46

The magnitude of the variability of samples for the different core locations is roughly of the order of analytical error for the particular parameter. From this it would be concluded that the location of the core sample in the bundle is not significant.

Applying Core Sampling to a Cane Evaluation System. A cane evaluation system should include the aspects of:

1. Direct cane quality criteria
2. Factory performance standards
3. A tentative recoverable sugar formula which includes the cane quality criteria and tentative factory performance standards
4. A means for factoring the tentative recoverable sugar to a standard factory performance

Direct Cane Quality Criteria. Assuming the sampling equipment and sample processing scheme are the same at all factories, direct cane quality criteria - as the name implies - are a function solely of the cane quality and might include: pol % cane, brix % cane, and fiber or insoluble residue % cane.

Pol % cane is the essence of cane quality. It is the measure of the richness of the cane. Were there no non-pol substance in the cane, the pol recovered in sugar should equal the pol in the original cane.

The magnitude of the losses in the boiling house is expressed by the term retention, which is the pol recovered in the sugar % pol in the extracted juice. Brix % cane is a measure of such losses since it is equated to the non-pol material in the cane (or juice) and expressed as brix - pol. From the Winter-Carp retention formula, it can be deduced that theoretically 1 part non-pol removes in the molasses 0.4 parts pol.

The magnitude of the loss in extraction is obviously related to the fiber or insoluble residue (natural fiber plus fiber in extraneous foliage and dry field soil), and each part of fiber or insoluble residue in bagasse is accompanied by a quantity of pol. Contrary to the soluble non-pol theoretical losses, losses associated with the insoluble non-pol (fiber or dry residue) are more difficult to establish.

Factory Performance Standards. Direct cane quality as brix, pol, and fiber is only a preliminary step in determining the ultimate criterion of recoverable sugar. The latter entails the aspect of factory performance. The key criteria of factory performance are pol extraction (pol in juice % pol in cane) and boiling house efficiency number (the percentage relation of the actual retention to the theoretical as determined by a standard retention formula such as the Winter-Carp expression).

To assure equity in cane quality evaluation, the same factory performance should be assumed; thus cane of the same direct quality should yield the same recoverable sugar.

A Recoverable Sugar Formula. To provide a means for immediate evaluation of the cane and a basis for pro-forma payment, the cane quality must be expressed in terms of a recoverable sugar formula which incorporates tentative factory extraction and boiling house retention standards.

Factoring the Tentative Recovery to a Standard Factory Performance. For final cane evaluation and subsequent cane payment, the theoretical recoverable sugar should be factored to a state-average factory performance by means of a liquidation factor. Such a factor relates the all-grower theoretically recoverable sugar to the total state sugar production as:

$$F = \frac{\text{Total sugar produced}}{\text{Total theoretically recoverable sugar}}$$

where, F is the liquidation factor

The corrected cane quality for each grower is then determined as the product of his total theoretically recoverable sugar and the liquidation factor.

On an interim basis - and until the entire state converts to the same cane sampling system - the sum of the theoretically recoverable sugar for all growers must be factored to a corrected factory sugar production assuming a standard extraction and boiling house efficiency for the factory in question.

Applying the 1972 Data to a Cane Evaluation Scheme. Until more extensive studies are conducted in 1973 with the press instead of the small mill, this merely represents one possible theoretically recoverable sugar formula and its application to the evaluation of cane quality.

For each run, the direct criteria of pol, brix, and fiber (or insoluble residue) % cane and the pol and brix % extracted juice were determined. For these studies, the Sx-By sugar formula was used. Developed by Arceneaux and based on the Winter-Carp formula (1) and first applied to a proposed cane payment system by Seip (8), the formula was used in the following form:

$$TRS = 29.17 (S) - 8.33 (B)$$

where: TRS is the theoretically recoverable sugar, lb 96° sugar/ton cane assuming 100% pol extraction and boiling house efficiency. S and B are the pol and brix % cane, respectively, calculated as the product of pol or brix % extracted juice x (100.00 - f) / 100. f is the fiber % cane.

The suggested formula recognizes that there is a distinction between the brix and the pol of the extracted juice and that of the absolute juice. However, in the absence of maceration water on the sample mill, the magnitude of the difference is small and this assumption lends itself to simplicity.

The calculated data are as shown in Table 7 where:

TRS = Theoretically recoverable sugar

RS = Predicted factory yield based on actual extraction and assuming the Winter-Carp retention formula and a boiling house efficiency of 97.20

CRS = Corrected recoverable sugar determined as:

$$TRS \times F$$

$$\text{where: } F = \frac{RS}{TRS}$$

Table 7. Correlation of theoretically recoverable sugar with factory yield.

Run	% cane		Lb 96° sugar/gross ton cane		
	S	B	TRS	RS	CRS
1	12.22	15.09	230.8	194.7	197.7
2	9.38	13.68	159.6	114.2	136.7
3	13.16	15.84	251.9	186.0	215.7
4	13.44	15.97	258.9	225.1	221.7
5	11.24	14.04	210.9	159.5	180.6
6	9.69	13.16	173.0	157.5	148.2
11	10.85	12.86	209.3	193.9	179.2
12	8.52	11.78	150.3	161.0	128.7
13	8.52	11.47	152.9	147.5	130.9
Average	10.78	13.77	199.7	171.0	171.0
r ²					0.6754
r					0.8218

$$F = \frac{\sum RS}{\sum TRS} = \frac{1539.4}{1797.6} = 0.8564$$

The correlation is statistically significant; however, a closer agreement for the individual runs of the factory yield and the corrected theoretically recoverable sugar would have been desirable. A very real problem in 1972 was the volume of field soil accompanying the cane consignments and the wide variability in the incidence of soil within the bundle as indicated by the appearance of the individual core samples.

The above correlation is deficient in several respects. First, 100% extraction efficiency is assumed in the theoretically recoverable sugar formula, i.e., all the absolute juice in the cane is assumed to be removed in the extracted juice. Second, the liquidation factor is based on the actual factory performance (extraction at least, since in not completing each run to sugar and molasses, a boiling house efficiency had to be assumed). In a commercial scale operation, the individual factory performance would have to be corrected to the all-state factory performance in order to assure that cane with the same TRS is valued at the same price regardless of the efficiency of the factory where the cane is processed. Finally, the pol and brix % cane calculated as the product of absolute juice times pol and brix % juice differs from the core sample data by about + 5%.

Streamlined Sample Analysis. The criterion of cane fiber infers an actual fiber determination for each core sample or composite of such samples. It is felt that this would be impractical where many samples are to be processed. The fiber determination developed by Tanimoto (9) for the hydraulic press analysis of prepared cane samples at the Hawaiian Experiment Station should lend itself ideally to a streamlined analytical procedure. Here the only analysis of the press residue or bagasse is a moisture determination. From the bagasse moisture (or water) and the moisture in the expressed juice (100 - brix), the juice in the press residue is calculated, and from this figure the juice in the sample is determined. The fiber is thus the difference between the sample weight and the total juice in the sample. Fiber by this method was compared to that determined by a complete analysis with good agreement. In calculations at the Audubon Sugar Factory, a similar approach was used to infer the brix and pol in bagasse and from these data the brix and pol % cane. These gave good agreement with samples processed in the hydraulic press - the processing scheme envisioned for the 1973 crop studies.

Some Data on the Conventional Sampling System. For each factory run, the conventional trash and sucrose samples were removed and processed. A single trash sample weighing about 100 lb was removed from the feeder table. Concurrently, 3 hand-grab sucrose samples of about 30 lb each were removed from different sections of the cane on the table. The trash samples were handled in the usual manner to determine trash % cane. Each of the 3 sucrose samples was ground in a single pass through the Farrel mill and the juice analyzed.

Table 8 shows for each run the individual sample mill brix and pol, the average value, and the standard deviation and coefficient of variation.

Table 8. Variability among sucrose samples from the same cane consignment.

Run	Sucrose sample				S.D.	C.V.
	1	2	3	Average		
<u>Pol % sample mill juice</u>						
3	16.18	16.13	16.48	16.26	0.1893	1.16
4	17.75	18.33	18.64	18.24	0.4518	2.48
5	14.05	13.49	14.38	13.97	0.4499	3.22
6	14.40	14.73	13.42	14.18	0.6813	4.80
7	15.02	16.16	16.09	15.76	0.6389	4.05
8	15.28	14.61	15.01	14.97	0.3371	2.25
9	15.36	14.75	15.01	15.04	0.3061	2.04
11	15.55	15.14	15.50	15.40	0.2237	1.45
12	14.41	14.09	12.76	13.75	0.8731	6.35
13	14.46	14.30	13.39	14.05	0.5771	4.11
Average				15.16	0.4728	3.19
<u>Brix % sample mill juice</u>						
3	18.82	18.72	18.82	18.79	0.0577	0.31
4	20.12	20.56	20.56	20.41	0.2540	1.24
5	17.01	16.61	17.27	16.96	0.3325	1.96
6	17.42	17.72	16.42	17.19	0.6807	3.96
7	17.28	18.08	18.18	17.85	0.4933	2.76
8	17.59	17.17	17.27	17.34	0.2194	1.26
9	17.84	17.47	17.74	17.68	0.1914	1.08
11	17.82	17.32	17.62	17.59	0.2517	1.43
12	16.66	16.66	15.46	16.26	0.6928	4.26
13	16.83	16.63	15.88	16.45	0.5008	3.05
Average				17.65	0.3674	2.13

The variability in juice quality among the 3 sucrose samples was slightly less than that among the 3 core samples which were removed from the same bundle. This is summarized below in a comparison of the coefficients of variation.

	<u>Coefficient of Variation</u>	
	<u>Core</u>	<u>Sucrose</u>
Pol % juice	4.06	3.19
Brix % juice	3.20	2.13

The difference between the core and sucrose samples reflects the effect of trash and would be expected. While the trash in the core sample is representative of that in the cane traversed by the corer, trash is lost in the procurement and transfer of the conventional trash sample. In view of the volume of trash (particularly field soil) encountered in the 1972 crop, it is of interest that the variability among samples by the different methods was as close as it was.

While the difference among sucrose samples from the same consignment was slightly less than that of the core samples, to the contrary, the core samples showed a considerably better correlation with the factory juice quality. Tables 1 and 2 cited previously compared the correlation of the core and sucrose sample juice quality with that of the crusher juice. These data are summarized below.

	<u>Brix and Pol Factors</u> <u>Coefficient of Variation*</u>	
	<u>Core</u>	<u>Sucrose</u>
	<u>sample</u>	<u>sample</u>
Pol factor	4.82	7.11
Brix factor	2.75	5.66

* Brix and pol factor = $\frac{\text{Crusher juice brix or pol}}{\text{Sample juice brix or pol}}$

As would be expected, the same order of variability would be reflected in a comparison of the sample mill brix and sucrose factors from the core sample juice data and the sucrose sample juice data. It will be recalled that these factors are the basis for determining the grower's normal juice quality from his sample mill inspections, the factors being a 5-day moving average of the daily factors calculated as follows:

$$\text{Sample mill brix factor} = \frac{\text{Factory normal juice brix}}{\text{Sample mill juice brix}}$$

The sample mill sucrose factor is calculated in a similar manner. A comparison of the factors as determined from the factory normal juice quality and the quality of the juice by each of the two sampling methods is shown in Table 9. With the exception of Run 4, a very definite drop in the sucrose sample factors remained relatively constant. Similar and more complete data in Tables 1 and 2 show the same trend.

Table 9. Comparison of sample mill juice brix and sucrose factors calculated from the sucrose and the core samples.

Run	Sample mill factors by sample method			
	Sucrose		Core	
	Brix	Sucrose	Brix	Sucrose
3	0.9675	0.9360	0.9811	0.9883
4	0.8114	0.7346	0.8804	0.8465
6	0.9570	0.8829	1.0668	1.1031
11	0.8977	0.8591	1.0148	1.0076
12	0.8684	0.7855	1.0043	1.0619
13.	0.8304	0.7388	1.0149	1.0380
Average	0.8887	0.8228	0.9937	1.0076

Assuming a reasonably constant fiber % cane, the juice content of all varieties and at different stages of cultivation (plant vs stubble) would be the same. The above assumption, or the assumption of minimal variation in fiber, formed the basis for cane evaluation procedure with hand-cut cane in the Louisiana normal juice and standard cane system and the Java ratio method (pol % cane/crusher juice pol) in overseas areas. With the conversion to mechanical harvesting in Louisiana, the aspect of trash was introduced and incorporated into the cane evaluation scheme with the concept of gross and net cane, the former being the weight of the cane as delivered and the latter the weight of the cane after deducting the trash. One effect of the trash deduction was to compensate for the decreasing volume of juice with increasing trash content.

While replicate sucrose and core samples were run and statistically analyzed in the current investigations, time did not permit replicates of the trash samples, and only one trash sample of the order of 100 lb was removed per run.

Few data are available covering actual tests on the reproducibility of trash samples and the relation to the predicted sugar yield. Viator's study which was presented in tabular form during the same technical session showed a wide scatter of data relating sample size to the trash % cane, with correlation coefficients of 0.13 and 0.24 (10). Keller (4) in 1958 presented data comparing trash as determined by the conventional sampling system with the trash in the consignment as determined by detashing the whole bundle. The ratio of actual trash to trash by sample for 35 tests was 1.592. In other words, the actual trash was half again as high as that determined by the test. Since these studies, the conversion from hand grab to mechanical grab for the sample removal is almost 100%. Nevertheless, even the most casual observation of a trash sampling operation indicates the placing of the mechanical grab tynes is a matter of judgement, and considerable trash is unaccounted for in the transfer from the vehicle to the feeder table and lost in the final transfer from the table to the sample pallet.

In summary, considerable doubt remains as to the accuracy and reproducibility of the trash sample determination, but time did not permit investigating this aspect in these investigations.

Correlation of yield by the Conventional Sampling System with Factory Yield. For those runs in which 3 replicate sucrose samples were removed and processed, a comparison was made between the predicted factory yield and the yield as indicated by the conventional sampling system in terms of commercially recoverable sugar. In the latter case, the factor of standard per gross ton of cane was determined from the trash sample and the factory normal juice sucrose and purity. The corresponding yield was determined from the 1972 crop commercially recoverable sugar table, which showed par or 12% sucrose cane to be equal to 165.3 lb sugar raw value per standard ton. Expressing the factory yield as 96° sugar and the yield by the conventional sampling system as raw value introduced a small error.

It will be noted that by using factory normal juice, the sample mill inspections are bypassed in these calculations. Had the sample mill inspection been used (with the sample mill brix and sucrose factors for the specific run relating sample mill to normal juice) the result would have been the same factory normal juice quality.

Table 10 shows the yield by the conventional sampling system as TRS and the factory predicted yield as RS.

Table 10. Correlation of theoretically recoverable sugar by the conventional sampling method with the predicted factory yield.

Run	Trash % cane	Normal juice		Lb sugar/gross ton	
		Sucrose	Purity	TRS	RS
3	11.46	15.22	83.74	195.4	186.0
4	4.00	13.40	80.92	212.9	225.1
6	6.00	12.52	76.13	162.2	157.5
11	14.00	13.23	83.79	165.4	193.9
12	5.50	10.80	76.49	137.7	161.0
13	19.23	10.38	75.97	107.0	147.5
r^2				0.7544	
r				0.8685	

Where: TRS = Theoretically recoverable sugar from the trash and sample mill inspections, the factory normal juice sucrose and purity, sucrose and purity factors relating net to standard tons, and the commercially recoverable sugar table for the 1972 crop.

RS = Factory yield for the actual factory extraction, the Winter-Carp theoretical retention formula and a boiling house efficiency number of 97.2

*Sugar expressed as raw value for the TRS and 96° for the RS.

While the conventional sampling system gives reasonably good correlation with the predicted factory yield, it reflects the most idealized conditions possible for the system. These include: a) The factory normal juice analyses were used to determine standard tons instead of the sucrose sample. As noted previously, the alternative procedure of using the sample mill inspections and the sample mill factors derived from the specific run would have given the same result. In practice, a 5-day moving average of sample mill factors is applied to the sample mill inspections. The variability inherent in the conventional sample mill factors was well illustrated in Table 9; b) The 100 lb trash sample is larger than that normally used, and it was removed and processed under careful supervision to ensure as representative a sample as possible with a minimum loss of trash in transfer from the table to the pallet.

CONCLUSIONS

1. Trash in the form of a large volume of field soil accompanying cane from wet fields poses a major problem in devising a workable cane sampling system.
2. A core sample is superior as a sensor of factory mill juice quality to the conventional whole-stalk sucrose sample due to the fact that the trash in the consignment is more adequately represented in the core than in the usual whole-stalk sample. Thus substitution of a core sample for the whole-stalk sucrose sample would in itself be an improvement over the present system. In view of the cost of the core sampler, this is a rather expensive increment of improvement when still retaining all the other aspects of the current system.
3. While the core sampler is an ideal method for procuring a sample representative of the quality of cane traversed by the corer, processing the sample in a 3-roll mill does not adequately reflect the trash in the consignment when it includes a large volume of field soil. Such material washes out into the juice and does not appear in the sample bagasse.
4. Preliminary tests with the vertical hydraulic press (which arrived too late for inclusion in the complete test series) indicate that contrary to the sample mill as a processing device, the press retains in the press residue or bagasse much of the field soil in the sample.
5. These studies should be continued in 1973 with the substitution of the vertical hydraulic press for the sample mill as a sample processing device.

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APPENDIX

Table A-1. Factory mill data.

Parameter	Run no.* and date								
	1 10/18	2 10/20	3 10/27	4 11/ 2	5 11/ 7	6 11/ 9	11 11/30	12 12/ 5	13 14/14
% cane: Trash	12.62	40.86	11.46	4.00	12.00	6.00	14.00	3.00	19.23
Maceration	20.23	22.80	0	22.14	21.24	19.56	19.24	23.30	25.44
Mixed juice	86.09	74.95	65.78	90.85	88.95	87.67	90.02	97.03	94.10
Bagasse	34.14	47.85	34.22	31.29	32.30	31.89	29.21	26.27	31.35
Pol	12.58	8.69	12.27	13.85	10.35	10.21	11.51	9.97	9.19
Brix	15.80	12.98	14.83	17.28	13.39	13.52	13.82	13.11	12.34
Fiber	14.48	20.05	15.10	13.98	13.78	13.98	13.72	11.63	13.82
Crusher juice: Brix	19.12	18.56	18.74	19.82	16.94	16.96	16.28	14.56	14.08
Pol	16.02	13.79	16.12	17.07	13.72	13.30	13.87	11.47	11.55
Purity	83.79	74.30	86.02	86.13	80.99	78.42	85.20	78.78	82.03
Mixed juice: Brix	15.47	13.56	18.08	16.67	12.81	13.32	13.76	12.21	11.65
Pol	12.39	9.24	15.14	13.49	9.98	10.14	11.53	9.34	8.85
Purity	80.09	68.14	83.74	80.92	77.91	76.13	83.79	76.49	75.97
Last roll juice: Brix	8.39	8.80	17.62	7.92	8.42	7.42	6.95	6.18	6.50
Pol	6.45	5.51	13.90	5.92	6.19	5.31	5.45	4.43	4.07
Purity	76.88	62.61	78.89	74.75	73.52	71.56	78.42	71.68	62.62
Bagasse: Brix	7.28	5.89	8.57	6.82	6.19	5.77	4.92	4.81	4.41
Pol	5.60	3.69	6.76	5.10	4.55	4.13	3.86	3.45	2.76
Moisture	50.30	52.20	47.30	48.50	51.15	50.40	48.10	50.90	51.50
Fiber	42.42	41.91	44.13	44.68	42.66	43.83	46.98	44.29	44.09
Pol extraction % pol in cane	84.80	79.68	81.15	88.48	85.80	87.09	90.20	90.91	90.59
Lb 96° sugar/gross ton cane	194.5	114.0	186.0	224.7	159.4	157.5	194.0	161.0	147.3

* Because of conflicting research, Runs 7, 8, and 9 core samples were frozen for later analyses. Because of evidence of deterioration they were not processed. Core samples only for Run 10. No mill run.

CANE WASHING AT LULA FACTORY

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Lula Factory, Inc.
Belle Rose, La.

Our 2 main objectives in the designing of a feeder table to obtain the best washing possible were:

1. To obtain a constant thin mat of cane approximately 12-18 in. thick.
2. To utilize the wash water in the best way possible.

We obtained this by designing a feeder table that consists of 2 sections, Section A and Section B. See Fig. 1.

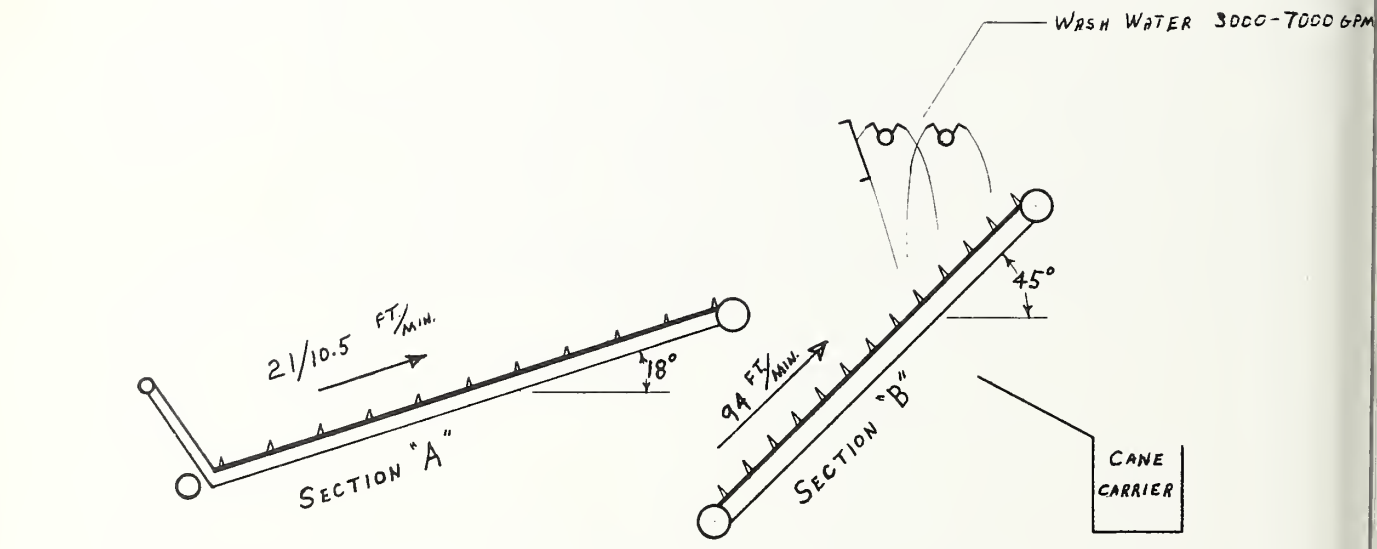


Fig. 1 Feeder table at Lula Factory.

Section A has 3 functions: 1) it receives cane from the yard, 2) it serves as a storage for Section B, and 3) it feeds Section B.

Section A is approximately 35 ft long and is set at an angle of 18° . Its feeder chains travel at one of two speeds: 21 or 10.5 ft/min. It is driven by a 2-speed 25 lc. motor with reduction gear and air operated clutch. It can be operated independent or continuously with Section B. There are 8 No. 678 heat rivetless feeder chains.

If we look at the front cut section of Section A (Fig. 2), we can see how the feeder chains are arranged. Section A has a solid bottom with 3 dead spaces, 14" wide, which separate the 4 sets of feeder chains. Each pair of feeder chains is connected by 2' x 3" x $1/4$ " angle irons every 3 ft. The lugs on these angle irons are 4 $1/8$ " high.

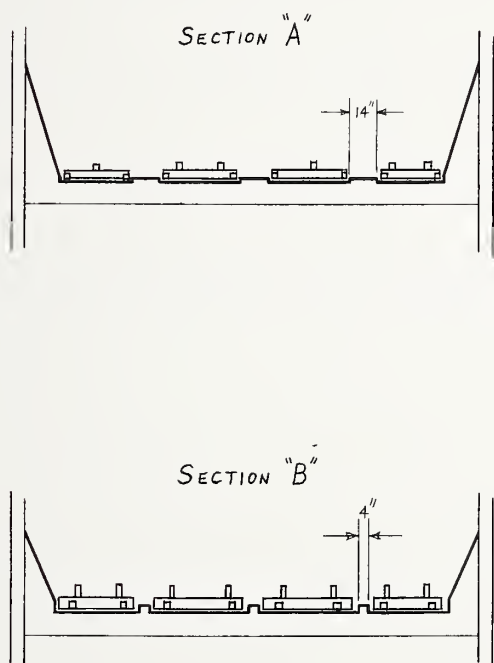


Fig. 2. Front-cut views of Sections A and B.

Section B has 3 functions also: 1) it maintains a continuous thin mat of cane approximately 12-18" thick, 2) it washes the cane, and 3) it feeds the carrier.

Section B is approximately 26 ft long and is set at an angle of 45° . Its feeder chains travel at a rate of 94 ft/min and also can be operated independently or continuously with Section A. It is driven by a 40 hp motor with reduction gear and air operated clutch. There are also 8 No. 678 heat treated rivetless feeder chains.

If we look at the front cut view of Section B, Fig. 2, we can see how these feeder chains are arranged. The bottom is also solid and has 3 dead spaces in it, but each of these is only 4" wide. Each pair of feeder chains is connected by a 3" x 3" x $1/4$ " angle iron every 2 ft. The lugs on these angle irons are 8 $1/2$ " high.

Why Section B at 45°? We found through experience that it took this steep an angle to insure self leveling of the cane. It doesn't matter if the cane is burnt or unburnt, we still get a constant thin mat of cane approximately 12-18" thick.

We also found that it gave us the most effective use of our wash water.

The wash water is introduced to the cane at the top of Section B at a rate of 3000-7000 gal/min.

Section B has a solid bottom and thus the wash water has a cascading effect and consequently we get the full benefit of the wash water.

Advantages of the washing system include:

1. We made the 1972 crop with only one set of knives.
2. The mill showed less wear than after the 1971 crop.
3. It enabled the mill to run at near capacity throughout the 1972 crop.
4. We did not suffer at the clarifiers and filter press stations as we did in 1971.
5. For our 1971 crop, with a rainfall of 15.75 in., we averaged 133 lb of mud per ton of cane. (Mud that came in the factory.) For the 1972 crop, with a rainfall of over 20 in., we averaged 102 lb of mud per ton of cane.

There are still some minor problems that we have with the table, but we hope to have these corrected for the next grinding season. Problems include:

1. Some trash from Section B.
2. Feeder chain jumps sprocket on Section A.
3. Section A chokes occasionally.

We at Lula are not saying that this feeder table is the perfect washing feeder table and that everyone should have one, but it has made a big difference at Lula Factory.

REUSE OF SUGAR MILL WASTE WATER

(This paper was not available for printing in the Proceedings).

CORRECTIONS FOR VOLUME 2

The only error in Volume 2 that was called to the attention of the editorial committee was in the author's name for the paper entitled "The Fourth Phase Which Affected the Long Term Successful Founding of the Florida Cane Sugar Industry", pages 22-29. Please change the author's name to B. A. Bourne. Our apologies are offered to Dr. Bourne for the error involved.

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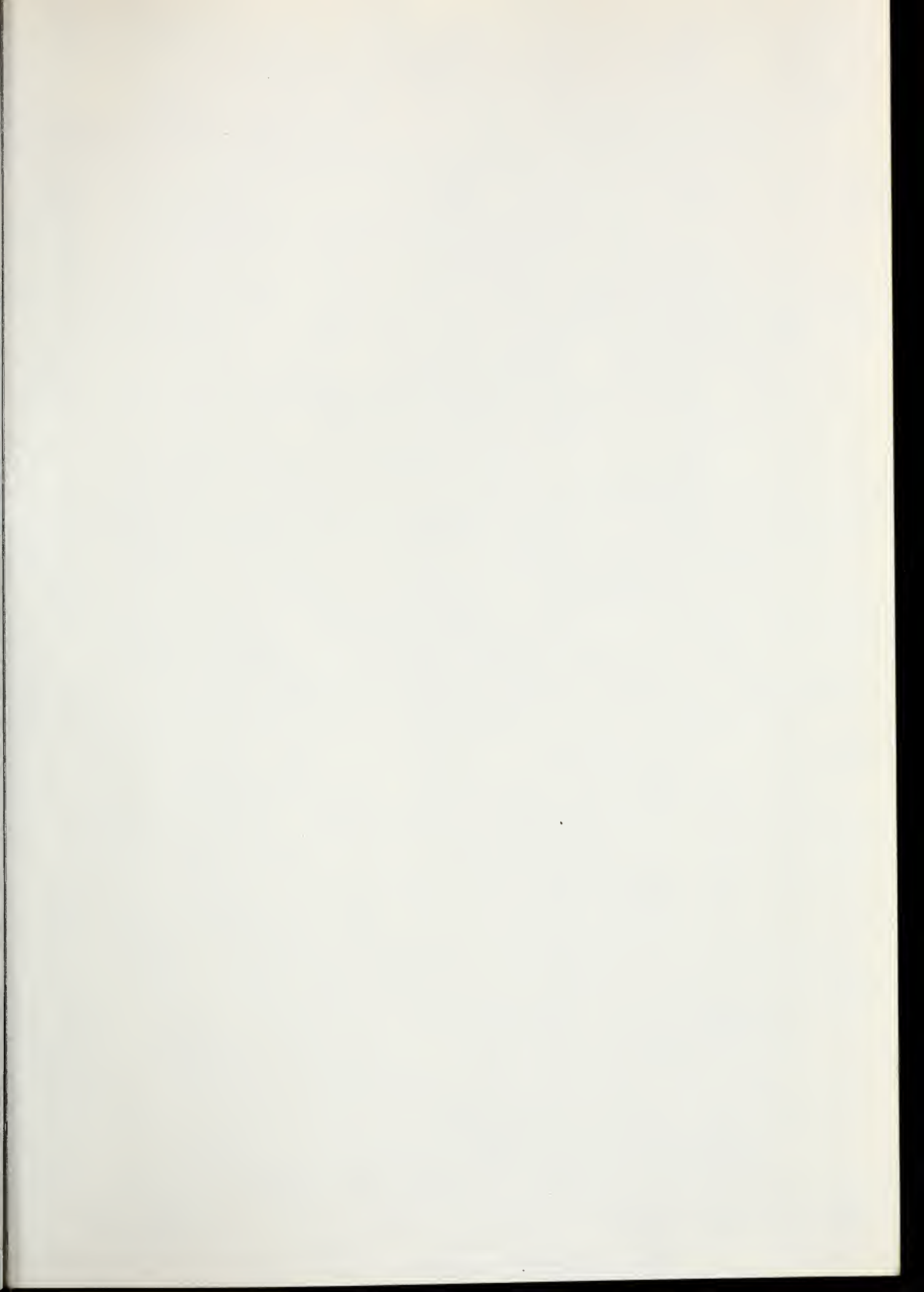
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